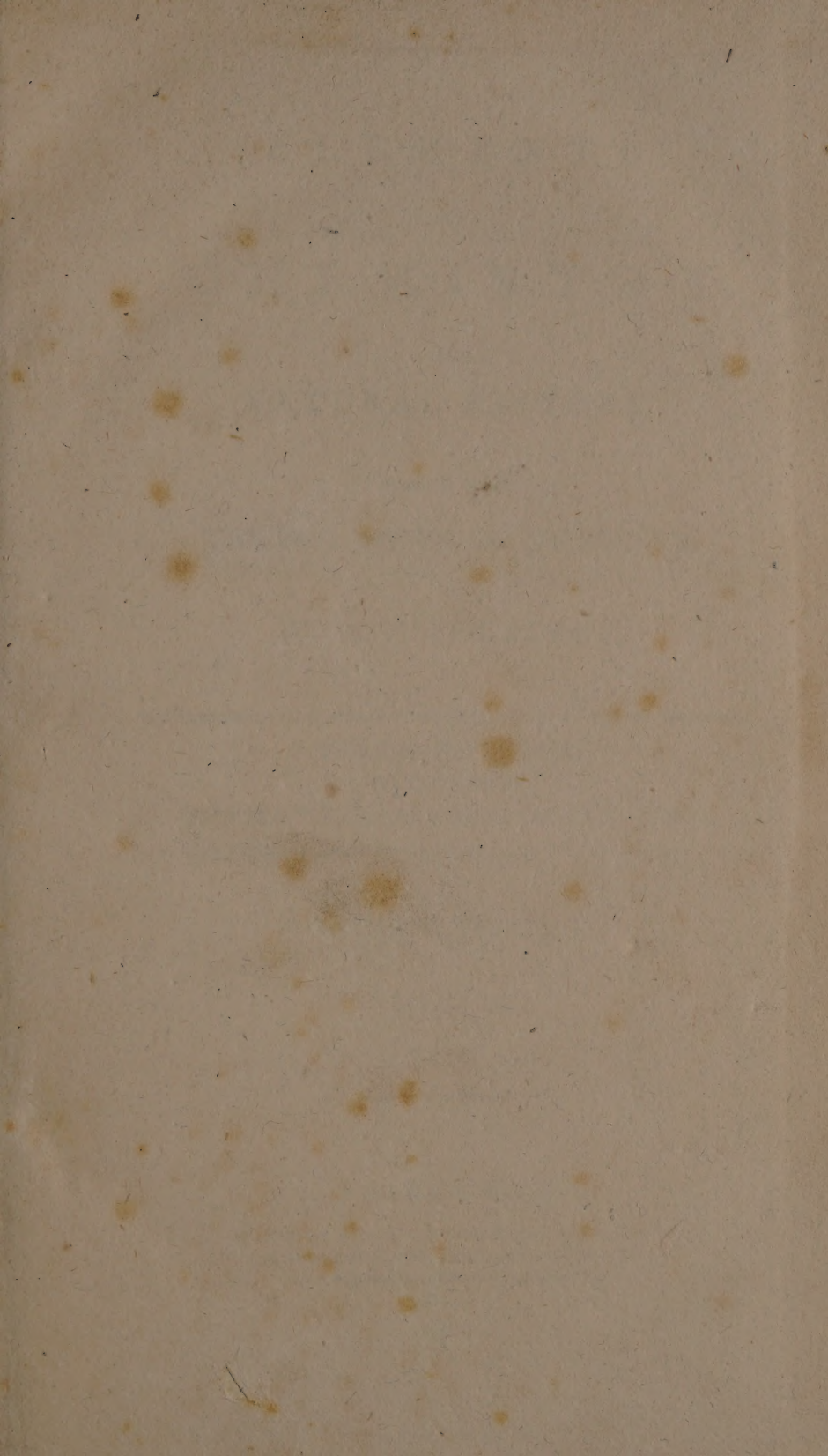


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E L E M E N T S
OF
C H E M I S T R Y
AND
N A T U R A L H I S T O R Y.

TO WHICH IS PREFIXED,
THE PHILOSOPHY OF CHEMISTRY.

BY A. F. FOURCROY.

FIFTH EDITION,
WITH NOTES,
BY JOHN THOMSON, SURGEON, EDINBURGH.

IN THREE VOLUMES.

VOL. III.

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ADVERTISEMENT.

THE Editor omitted to mention in the Advertisement to Volume the First, that the Notes which are inserted at the bottom of the pages in this Edition, and which are marked with the letter T. are the Notes of Mr. Nicholson.

He takes also this opportunity to acknowledge, that he is indebted to his Friend Mr. Allen for the Notes on Affinity and Air, together with the more valuable part of the Notes on Caloric, contained in the First Volume, and for the greater part of the Notes on Animal Substances contained in the Third Volume.

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ELEMENTS
OF
NATURAL HISTORY
AND OF
CHEMISTRY.

PART II.

CHAPTER XXIII.

GENUS VI. CONCERNING BITUMENS IN GENERAL *.

BITUMENS are combustible, solid, soft, or fluid substances, whose smell is strong, acrid, or aromatic, and which appear to be much more compounded than those bodies of the mineral kingdom we have hitherto examined. They are found either in strata, in the internal part of the earth, or exuding through the clefts of rocks, or floating on the surface of waters. Their character is to burn most commonly with a rapid flame when heated with contact of air, like those matters formed by the organs of vegetables and animals, and distinguished by the name of *oils*. Their analysis is much less perfect than that of earthy, saline, or metallic matters; because the action of fire greatly alters them, and developes principles which re-act on

* It is proper to remind the reader that we have divided combustible minerals into five genera, viz. diamond, hydrogen gas, sulphur, metals, and bitumens. F.

each other, in proportion as they are volatilized. In this respect bitumens resemble vegetable and animal substances. By distillation they afford water, or an odorous phlegm, more or less coloured, a saline acid salt, often concrete, sometimes ammoniac and oils, light towards the beginning, and more thick and coloured in proportion as the distillation advances, and the fire is more active. After this analysis a coal remains, which in the different species of bitumens is either dense, light, brilliant, or compact. This analysis shows, that these inflammable substances have a vegetable or animal origin, as we shall observe more fully after we have spoken of their general properties.

Bitumens are subject to some alterations from light. When fluid, their colour becomes deeper, and their smell is changed, if preserved in transparent vessels. The air thickens them by the successive evaporation of their moisture, which is taken up so much the more readily as the air is drier. Their odorous principle, or spiritus rector, is dissipated in the same manner, as they gradually pass from the state of fluidity to that of tenacity and solidity. A great number of years however are necessary to produce this last alteration.

Water, in which bitumens are boiled, does not dissolve them, but it becomes charged with their aromatic principle, and emits the peculiar smell of the bitumen. It seems, therefore, that water has a stronger affinity with the odorant principle, than the oily matter of the bitumen; and that the whole smell of these substances might perhaps be taken away in this manner.

The action of the saline-terrestrial substances on bitumens has not yet been examined; lime, however, as well as pure alkalis, seems capable of uniting with these combustible matters, and forming compounds soluble in water, which are called soaps.

The manner in which the mineral acids are capable of acting on bitumens, is not known. It is probable, that they would dissolve or burn them according to their state of concentration, as they do oils.

The action of neutral salts, of hydrogen gas, of sulphur, and of metals, on bitumens, has not been examined; and in general the chemical properties of these substances are but little

known. This field of experiment is entirely new, and certainly promises valuable and useful results.

Natural historians have paid a much greater attention to the origin and formation of bitumens, than chemists have to their analysis. There have been many opinions respecting this subject. Some have thought that these combustible substances properly belong to the mineral kingdom, and that they have the same relation to minerals, as oils and resins have to organic substances. This analogy, though striking to the imagination, does not agree with the facts, for there is no substance in the mineral kingdom which possesses the oily character. The opinion of those therefore, who attribute the origin of bitumens to vegetable substances buried in the earth, and altered by the action of mineral acids, has met with a much better reception. In fact, every circumstance proves, that bitumens are produced from organic substances. A great number of bodies of this kind, whose form is still distinguishable, is constantly found in their vicinities; they have, besides, the chemical characters of substances formed by the processes of animation, and have been imitated, in a certain degree, by combining oils with the concentrated sulphuric acid. We shall see in the chemical history of vegetable substances, that this acid, in contact with essential oils, hardens and blackens them, and communicates to them a strong and penetrating smell, resembling that of bitumens. But can it be asserted that these substances are in all cases formed by vegetable substances buried in the earth, as most naturalists have affirmed, and that animal substances have contributed nothing to their formation? The great quantity of bitumens which exist in the interior part of the earth, compared with the small quantity of wood and of trees found in their vicinity, and more especially the small proportion of oily matter contained in vegetables, seem to contradict that opinion which attributes the origin of bitumens solely to productions of the vegetable kingdom; on the other hand, the abundance of these combustible bodies in places where scarcely any traces of vegetables are found, and the almost constant existence of the exuviae of animals heaped above bitumens, may induce us to believe, that these organic beings have contributed greatly, and perhaps even more than vegetables, to

the formation of some of the kinds. We may likewise observe, that the successive strata of certain bitumens which are found in continued masses in the internal part of the globe, prove, that these substances have been deposited slowly, and by means of water; and that their formation corresponds to the era in which immense masses of shells, or other marine substances, have been formed by the sea. They have, therefore, been in a fluid state, and are become hard by the lapse of time and the unremitted action of saline, or other agents, which the interior part of the earth contains in large quantities. Such is the opinion which Parmentier, member of the College of Pharmacy has exhibited, respecting the origin of pit-coal, in a memoir which he read at the opening of the course of lectures before that Society. The oils and fats of marine animals appear, therefore, to be one of the matters used by nature in the formation of certain bitumens; while there are others, whose origin is manifestly vegetable, and arises from the resins or essential oils, buried and changed in the earth.

The number of bitumens is very considerable. Naturalists have divided them into several genera. As we here consider them chemically, we shall divide them into *species* or *kinds*; because they have all, in fact, the same characters relative to their chemical properties; some are liquid, others are of a soft consistence, and others are solid, among which last some are hard and susceptible of a polish, while others are friable. We are acquainted with five species, very distinct from each other, which may comprehend a great number of varieties. These five species, whose history we shall proceed to recite, are succinum, asphaltos or bitumen Judaicum, jet, pit-coal, and petroleum. Ambergris is no longer to be ranged among bitumens, but among the productions of the animal kingdom.

CHAPTER XXIV.

SPECIES I. SUCCINUM AND THE SUCCINIC ACID.

SUCCINUM, called *yellow amber* or *karabé*, the most beautiful of all the bitumens, is found in irregular masses of a yellow or

brown colour, either transparent or opaque, of a stratified or scaly texture; it takes a very good polish; after a slight rubbing it becomes electric, and attracts straws and small bodies. The ancients, who were acquainted with this property, gave amber the name of *electrum*, whence the modern term electricity is derived.

This bitumen is of a considerable hardness, approaching to that of certain stones, which induces Hartman, a naturalist who lived towards the conclusion of the last century, to rank it among precious stones, though it is friable and brittle. When pulverized it emits an agreeable smell. Insects, in a fine state of preservation, are often found within it, which proves that it has been liquid, and in that state has enveloped those small bodies. Amber is usually dug out of the earth at various depths; it is found under coloured sands in small incoherent masses, and dispersed on strata of pyritaceous earth: above it wood is usually found, charged with blackish bituminous matter; whence it has been concluded, that it is formed by a resinous substance altered by the sulphuric acid of pyrites. It likewise is found floating on the banks of the sea; as for example, on the shores of the Baltic in Ducal Prussia. The mountains of Provence near the town of Sisteron, the Marquisate of Ancona and the Duchy of Spoleto in Italy, Sicily, Poland, Sweden, and many other countries likewise afford it. The colour, texture, transparency, or opacity of this bitumen, have caused it to be distinguished into a considerable number of varieties, which, after Wallerius, we may reduce to the following:

Varieties.

1. White transparent amber.
2. Pale yellow transparent amber.
3. Orange yellow transparent amber.
4. Golden yellow transparent amber, *chryseletrum* of the ancients.
5. Deep red transparent amber.
6. Opaque white amber, *leuceletrum*.
7. Opaque yellow amber.
8. Opaque brown amber.
9. Amber, coloured green or blue by foreign substances.
10. Veined or clouded amber.

It may likewise be distinguished into a great number of varieties, according to the accidental circumstances its internal parts present; but it is necessary to observe, with respect to the price of the specimens of amber remarkable for their magnitude, their transparency, or the well preserved insects contained within them, that it is possible to be deceived in this respect, since many persons possess the art of giving it transparency or colour at pleasure, and of softening it sufficient to introduce foreign bodies. Wallerius affirms, that the gold-coloured amber never owes its transparency to art, but that which art has rendered transparent, is always of a pale colour.

Though it is probable that this bitumen owes its origin to resinous vegetable matters, many naturalists have entertained different opinions respecting its formation; some have considered it as the indurated urine of certain quadrupeds; others as a bitumen detached from the earth by the sea, which is become hard and dry by the action of the sun's rays. This class of naturalists consider it as a peculiar mineral juice; such was the opinion of an ancient naturalist named Philemon, and quoted by Pliny. George Agricola revived this opinion; Frederic Hoffman supposed it to be formed out of a light oil, separated from bituminous woods by heat, and thickened by the sulphuric acid. This opinion of Hoffman cannot, however, be admitted, because it is not conceivable how an oil separated in the bowels of the earth, can enclose and contain animals which live only at its surface. It has hitherto been thought, that amber is a resinous juice which flows from some tree; that this juice, buried more or less deeply in the earth, by the convulsions the globe has experienced, becomes hardened by impregnation with the mineral and saline vapours which circulate within the earth. It is not probable that it has been altered by concentrated acids; for experience teaches us, that the action of these acids would have blackened it, and converted it into the state of coal. Pliny thinks that amber is nothing but the resin of the pine, hardened by the colds of autumn. M. Girtanner thinks, that it is a vegetable oil rendered concrete by the acid of ants; it is that species of ants called *formica rufa* by Linnæus, which prepares it, according to this author. These insects dwell in old forests of fir trees, where the fossil amber

is found, which is ductile like wax, and becomes hard by exposure to air.

Amber, exposed to the fire, does not liquefy, but by a considerable heat it softens and swells very much; when heated with contact of air it takes fire, and emits a very thick and odorous fume; its flame is yellowish, variegated with green and blue; and after its combustion it leaves a bright black charcoal, which by incineration affords a very small quantity of black brown earth. Bourdelin, in his Memoir on Amber (Acad. 1742), obtained but 18 grains of this earth by burning two pounds of amber; half a pound of the same bitumen burned and calcined in a crucible, afforded him, in a second operation, twelve grains of earthy residue, from which he extracted iron by the magnet.

Amber distilled in a retort by a heat gradually raised, affords a phlegm of a red colour, and manifestly acid; this acid liquor retains the strong smell of amber: an acid volatile salt afterwards passes over, which crystallizes in small white, or yellowish needles, in the neck of the retort. This salt is succeeded by a white and light oil of a very penetrating smell; the oil by degrees becomes coloured in proportion as the heat is raised, and towards the end is brown, blackish, thick, and viscid, like the empyreumatic oils: while these two oils pass, a certain quantity of volatile salt, more and more coloured, is sublimed. The residue, after this operation, is a black mass of the figure of the bottom of the vessel, brittle, and resembling bitumen Judaicum. George Agricola made the same observation near three centuries ago, on the residue of distilled amber. If the operation be managed by a gentle heat, cautiously conducted, and the quantity of amber be considerable, these products may all be obtained separately, by changing the receivers. It is usual however to receive them in the same vessel, and afterwards to rectify by a gentle heat; the acid is partly discoloured by this rectification. The oil, which becomes black at the end of the operation, on account of the carbonaceous portion, and because the acid has acted on its principles, may be rendered very clear and light by several successive distillations. Rouelle the elder has described a very good process for obtaining it in this state by one operation:

for this purpose the oil must be put into a glass alembic with water, and distilled by the heat of boiling water; the purest portion, or the oily part which is volatile at this degree of heat, on account of its levity, passes over with the water, above which it floats in the receiver; if it be designed to preserve it in this state, it must be kept in vessels of stone-ware; for the rays of light which pass through glass vessels give it a yellow, and even a brown colour in process of time.

This analysis shows, that amber consists of a large quantity of oil rendered concrete by an acid, and that it likewise contains a very small quantity of earth, whose nature has not been yet examined, with a few particles of iron.

The oil of amber appears to resemble essential oils in volatility, smell, and inflammability: it seems capable of forming soaps with alkalis.

The volatile salt of amber was for some time considered as an alkaline salt. Glaser, Lefevre, Charas, and Jean-Maurice Hoffman, professor at Altdorf, were of this opinion. Barchusen, and Bolduc the elder, were the first chemists who, in the last century, observed the acid nature of this salt. All subsequent chemists have admitted this discovery, but they have not agreed concerning the nature of the acid. Frederic Hoffman, from the consideration that amber is found in Prussia among the strata of matter filled with pyrites, imagined that this salt is formed from the sulphuric acid. Neumann appears to be of the same opinion. Bourdelin, in the Memoir we have quoted, relates several experiments he made to determine the nature of this salt: He first observes, that the salt of amber obtained by distillation, however white and pure it may appear, always contains an oily substance; and it is doubtless to this oily substance that its smell, and the degree of combustibility it exhibits when thrown on burning coals, are owing: he tried several methods of depriving it of this substance. We shall see when we examine the nature and properties of alcohol, that this fluid could not answer his purpose; neither was the fixed alkali alone which he digested on amber with the intention of depriving it of its fat and oily part, and of obtaining its salt separate, attended with greater success; it only dissolved a small quantity of the bitumen, and assumed a lixivial

and saline taste, resembling that of sea salt. Lastly, Bourdelin could not discover a better process for uniting the pure acid of amber, deprived of oily matter, with fixed alkali, than to detonate a mixture of two parts of nitre with one part of the bitumen: he lixiviated the residue of this detonation with distilled water; the lixivium was of an amber colour, precipitating the solution of silver in white scales, and that of mercury of the same colour. Many other metallic solutions were likewise decomposed by it, but Bourdelin considered only the two first as conclusive: they appeared to him to show, that the acid of amber was the same as that of marine salt, since it presented the same phenomena as this last with the nitric solutions of mercury and silver. The lixivium of the residue of the detonation of amber with nitre afforded, by evaporation in the air, a mucilaginous substance, in the middle of which square elongated crystals were deposited; whose form, saline taste, decrepitation on hot coals and more particularly the considerable effervescence and odour of marine acid, which they emitted by the affusion of concentrated sulphuric acid, convinced this author that this muriatic acid was united with the base of nitre. Notwithstanding this analysis, which is very exact for the time of Bourdelin, the chemists who examined the salt of amber since his time, did not find it analogous to the muriatic acid, but discovered in it all the characters of an oily vegetable acid. Bergman, who appears to have adopted this opinion, gives the following account of the elective affinities of this salt. The succinic acid obtained by sublimation, and purified by successive solutions and crystallizations, forms crystallizable and deliquescent neutral salts, with potash and ammoniac; with soda it affords a salt which does not affect the moisture of the air; with lime or barytes, it constitutes salts of difficult solubility; magnesia forms with it a thick matter, resembling gum; it dissolves metallic oxyds; and the succinats produced by these solutions are for the most part crystallizable and permanent.

Barytes, lime, and magnesia, according to him, take the succinic acid from alkalis; barytes decomposes succinats of lime and magnesia; and lime-water precipitates magnesia from this acid ^a.

The examination of the chemical properties of this bitumen

has not been carried farther ; it is not even known in what manner the other acids act upon it. Frederic Hoffman affirms, that it may be totally dissolved in a lixivium of caustic alkali, and in the sulphuric acid. It is known, that the essential oil of amber unites with the caustic ammoniac, and forms by simple mixture and agitation a kind of liquid soap, of a milky white, and very penetrating odour, known in pharmacy by the name of *Eau de luce* ; and lastly, that this same oil dissolves sulphur by the assistance of the heat of a sand-bath, and constitutes a medicine called *succinated balsam of sulphur*.

Amber is used in medicine as an antispasmodic ; it has been recommended in hysteric and hypochondriacal affections, the suppression of the monthly courses, the gonorrhœa, fluor albus, &c. It is used in substance, after having been washed with hot water, and reduced into fine powder by levigation ; it is used in strengthening and resolving fumigations, by throwing the powder of this bitumen on a very hot brick, and directing the fumes to the part proposed to be acted on. The liquid acid and salt of amber are regarded as cordial and antiseptic ; they are administered also as powerful diuretics. The oil of amber is externally and internally used for the same purposes as amber itself, but is prescribed in smaller doses, on account of its greater activity. The succinated balsam of sulphur, which is given in the dose of a few drops, in proper fluids, or mixed with other substances to form pills, is found successful in pituitous affections or defluxions of the breast, the reins, &c. A syrup, called *syrup of amber*, is made with the liquid acid of amber and opium, and advantageously used as a sedative, anodyne, and antispasmodic remedy. *Eau de luce*, which is prepared by pouring a few drops of oil of amber into a bottleful of caustic ammoniac, and agitating the mixture till it becomes of a white milky colour, has been long used as a powerful stimulant in fainting fits. It is held to the nose, whose nerves it stimulates, and by the sneezing which it stimulates, the fluids are put in motion, and the patient recovers.

The finest pieces of amber are cut and turned into vases, heads of canes, necklaces, bracelets, snuff-boxes, &c. These kinds of toys are no longer esteemed among us, since diamonds

and jewellery are become more known; but they are carried into Persia, China, and other nations, who still esteem them as great rarities. Wallerius affirms, that the most transparent pieces may be used to make microscopes, burning glasses, prisms, &c. It is affirmed, that the King of Prussia has a burning mirror of amber, of a foot in diameter; and that there is a column of amber, ten feet in height, and of a beautiful lustre, in the cabinet of the Duke of Florence. Two pieces of this bitumen may be stuck together, by smearing them with a solution of potash, and pressing them together hot.

CHAPTER XXV.

SPECIES II. ASPHALTOS.

ASPHALTOS, or *bitumen Judaicum*, called also *funeral gum*, *amber of Sodom*, *mountain pitch*, *balm of mummies*, &c. is a black, ponderous, solid shining bitumen, which breaks readily with a vitreous fracture. A thin piece of this bitumen appears red, when placed between the eye and the light. Asphaltos has no smell when it is cold, but acquires a slight smell by rubbing. It is found on the waters of the lake Asphaltites, or the Dead Sea, in Judea, near which were the ancient towns of Sodom and Gomorrah. The inhabitants, incommoded by the smell emitted by this bitumen on the surface of the waters, and allured by the profit they derive from it, are careful in collecting it. Lemery, in his *Dictionnaire des Drogues*, affirms, that the asphaltos sweats out of the earth, in the form of a liquid pitch; and rising above the waters of the Dead Sea, is condensed by the heat of the sun, and the action of the salt, which those waters contain in large quantities. It is likewise found in several lakes in China.

The asphaltos in commerce is obtained, according to Valmont de Bomare, from the mines of Daunemore, and especially in the principality of Neufchatel and Wallengin. It is of two colours, according to this naturalist, blackish and greyish, or fawn-colour; but this asphaltos is far from being pure, and seems to be merely an earth, hardened and penetrated by the bitumen.

Naturalists are divided in their opinion respecting the origin of asphaltos, as well as of all other kinds of bitumen: Some suppose it to be a mineral product, formed by an acid, united with a fat substance, in the bowels of the earth; others consider it as a vegetable resinous substance buried, and altered by the mineral acids. The most generally received, and most probable opinion, is, that it has the same origin as amber, and is formed of this last bitumen, changed by the action of subterraneous fires ^b. This opinion is founded on the circumstance, that amber, melted and deprived of a part of its oil and of its salt by the action of fire, becomes brittle, and perfectly similar to asphaltos: but this doctrine cannot be solidly established, but by a comparative analysis of this residue of amber, and of asphaltos; and the latter bitumen has not been yet examined with all the accuracy which is necessary to establish the analogy.

Asphaltos, exposed to heat, liquefies, swells up, and burns with a flame and thick smoke, whose smell is strong, acrid, and disagreeable: by distillation, it affords an oil of the colour of brown petroleum, and an acid phlegm.

Asphaltos is employed by the Arabians and Indians for the same purposes as pitch, in coating their vessels, &c. It enters into the composition of the black varnish of china, and the artificial fires which burn on the surface of water. The Egyptians used it to embalm their dead; but it was employed only by the poor, who could not procure more precious antiseptic substances. Wallerius affirms, that a kind of asphaltos is prepared, in commerce, with thickened pitch, or by mixing and melting the latter with a certain quantity of true balsam of Judea; but this fraud may be discovered by means of spirit of wine, which entirely dissolves the pitch, and only takes a pale colour with asphaltos.

CHAPTER XXVI.

SPECIES III. JET.

JET, called by the Latins *gagas*, *black amber* by Pliny, *pangitis* by Strabo, &c. is a black bitumen, hard and compact, like

certain stones ; brilliant and vitreous in its fracture, and capable of taking a good polish. By friction it attracts light substances, and appears to be electric, like amber : it has no smell, but when heated, it acquires one nearly resembling that of bitumen Judaicum.

Jet is found in France, in Provence, and in the county of Foix ; there is likewise a quarry where it is extracted at Belestat, in the Pyrenean mountains ; it is likewise found in Sweden, Germany, and Ireland. Jet is found disposed in strata which contain pyrites, in which it resembles the strata of coal, and most other bitumens.

This bitumen softens and melts ; when strongly heated, it burns with a fetid odour ; by distillation it affords an oil and an acid.

Among the different opinions respecting the formation of jet, the most probable is that which supposes it to consist of asphaltos, hardened by time. This opinion has been adopted by the learned Wallerius &c.

Jet is used to make mourning toys. It is wrought, at Wirtemberg, into bracelets, buttons, boxes, &c.

CHAPTER XXVII.

SPECIES IV. PIT-COAL.

THE name of *fossil-coal*, *pit-coal*, *stone-coal*, *lithantrax*, &c. is given to a black foliated bituminous matter, either of a bright or dull appearance, which easily breaks, and has neither the consistence nor the purity of the bitumens before described.

This bitumen has received the name it bears, in consequence of its combustible property, and the uses it is applied to in many countries. It is found within the earth, below stoney beds of various degrees of hardness, and alluminous and pyritaceous shift. The latter constantly bear the print of several vegetables of the family of fern, most of which, according to the observation of Bernard de Jussieu, are exotic. Pit-coal is found at various depths within the earth ; it is disposed in horizontal or inclined strata, the latter disposition being the

most usual ; the beds, or strata of which it is composed, differ in thickness, consistence, colour, weight, &c. Beds of shells, and fossil madrepores, are often observed above the strata of this bitumen, which has induced several moderns, particularly Parmentier, to conclude that pit-coal has been formed in the sea, by the deposition and alteration of oily or fat marine substances. Most naturalists consider it as the product of a residue of woods buried in the earth, and altered by acids.

The mines of fossil-coal are wrought in the same manner as other mines, by digging shafts and drifts, and detaching the pieces of this bitumen by pick-axes. The miners are often exposed to the danger of losing their lives by the elastic fluids which are disengaged. The kind of mephitic called *choak-damp* extinguishes their candles, and appears to be the carbonic acid ; a kind of inflammable gas is likewise developed in mines, which sometimes produces dangerous explosions.

Fossil-coal is very abundant in nature ; it is found in England, Scotland, Ireland, Heinault, Liege, Sweden, Bohemia, Saxony. Many provinces in France afford it in abundance, especially Burgandy, Lyons, Forez, Auvergne, Normandy, &c.

Fossil-coal is distinguished into stone-coal, or earthen-coal, according to its hardness and friability ; but the manner in which it burns, and the phenomena it presents during its combustion, afford characters much better adapted to distinguish the different sorts. Wallerius distinguishes three sorts under this point of view : 1. The scaly coal, which remains black after its combustion. 2. The compact and laminated coal, which after being burned, affords a spongy matter, similar to scorix. 3. Fibrous pit-coal, resembling wood, which is reduced into ashes by combustion^d.

This bitumen, heated in contact with the air, burns more slowly and difficultly, in proportion as it is more heavy and compact. When once perfectly set on fire, it emits a strong and durable heat, and is long before it is consumed ; it may even be extinguished, and used several successive times for new combustions. Its inflammable matter appears to be very dense, and, as it were, fixed by another incombustible substance, which prevents its dissipation. It emits a peculiarly strong smell,

which, however, is not at all sulphureous when the coal is very pure, and does not contain pyrites. The combustion of this bitumen appears to resemble that of organic substances, particularly in the circumstance of its being capable of being interrupted, and burned again. In fact, the most volatile, oily, and most combustible part of pit-coal, is dissipated and inflamed by the first action of the heat; and if the combustion be extinguished when this principle is dissipated, the bitumen retains no more than the most fixed and least inflammable part of its oil, reduced into a true coaly state, and combined with an earthy base. By a process of this nature the English prepare their *coaks*, which is pit-coal deprived of its oily fluid by the action of fire. What happens in this experiment is easily shown, by heating the bitumen in closed vessels, with the proper apparatus for distillation: an alkaline phlegm, concrete carbonat of ammoniac, and an oil, which becomes of a deeper colour, and more heavy, in proportion as the distillation advances, are obtained; at the same time that a great quantity of elastic and inflammable fluid is disengaged, which is supposed to be oil in the vaporous state, but is in fact a kind of hydrogen gas mixed with azotic gas, holding carbon in solution, and carbonic acid: in the retort there remains a scorified carbonaceous matter, still capable of burning, which is the *coak* of the English. If the action of fire on pure pit-coal be attended to, it is seen that it suffers an evident softening, and appears to undergo an imperfect fusion*; and as this state might be prejudicial to the fusion of ores, it is necessary to deprive the coal of this property: the principle on which the softening depends being taken away, namely, the oil which it contains in great abundance, the coal is reduced into a state analogous to that of charcoal made with vegetables. We must not forget to observe, that the ammoniac abundantly furnished

* There are some species of coal which do not undergo this fusion, or rather softening, by means of caloric. These kinds do not seem to contain so much oil as those which soften in the fire; but the last are the most frequent, and the best. The distinction of pit-coal into different kinds is not at present so accurate as it may yet be made. Foujas has thrown some light on this subject in a dissertation which he published some months since on pit-coal. F.

by pit-coal. As soon as the experiments we have urged respecting its animal origin, have been made elsewhere seen, the substances afforded by the mineral kingdom always afford this salt by distillation. This analysis of coal is made in the large way in many parts of England; and the different products of pit-coal are collected in a peculiar distillatory apparatus: the oil is employed instead of pitch, the ammoniac serves the manufactories of sal-ammoniac, and the residue is an excellent coak. M. Faujas de Saint Fond has transported this useful art into France, and the experiments he has made at the Botanic Garden have succeeded perfectly well*. Notwithstanding this, there is still no other work of this kind erected on a large scale.

Pit-coal is singularly useful in countries where wood is scarce: it is employed as fuel, without any of that danger attributed by certain persons to its use; for the sulphureous vapour, which has been said to be spread abroad during its combustion, is not to be feared, since the most accurate analysis has proved, that when pit-coal is very pure, it does not contain the smallest portion of sulphur. Hence we may perceive how false and fallacious are the pretences of certain ignorant persons, who affirm that they are in possession of processes to deprive this bitumen of its sulphur. Another consideration which ought to engage us, especially in France, to use pit-coal, is, that the mine-works consuming immense quantities of charcoal, there is reason to fear that wood will, at no very distant period of time, become scarce; and it is more especially in those kinds of works that pit-coal ought to be used, as it long has been by the English. It is already beginning to be used in various manufactories, of which the famous iron founderies at Creusot, near Mount Cenis in Burgundy, exhibit a great and useful example.

* Every principle of justice and equity demands that the name of Lord Dundonald should not be passed over in silence when this art is spoken of. It is this gentleman, who, having the spirit to risk his fortune on a rational and highly beneficial project, has done more service to his country, and mankind at large, than if he had discovered an hundred gold mines. The coak and mineral tar are of infinite utility in the arts; but I do not know whether the volatile alkali of this process is cheaper than that usually obtained from bones, nor whether the oil is applied to commercial purposes.—T. Dundonald.

Purified pit-coal consists of coal deprived of its oil by the action of fire. This kind of charcoal burns without smoke, without becoming soft, and without emitting any strong smell: in a word, it is a true coak, and is preferable as fuel to be burned in the apartments of a dwelling house.

One of the greatest inconveniencies of pit-coal, besides the very abundant and thick smoke it emits, and which blackens furniture, is, that the very rapid and abundant current of air it requires for its combustion raises and volatilizes part of its ashes, which fix themselves to the surrounding bodies; but these two inconveniencies may in a great measure be remedied by well-constructed chimneys, so that the current excited by the combustion may be entirely carried out of doors, without any part of it returning into the chamber.

The utility which this combustible substance will be of in France is much greater with respect to the arts and manufactures of every kind; and by availing ourselves of this fuel, wood for building, and other purposes, will be rendered cheaper.

CHAPTER XXVIII.

SPECIES V. PETROLEUM.

THE name of *petroleum*, or *oil of stone*, is given to a liquid, bituminous substance, which flows between stones or rocks, or in different places at the surface of the earth. This oil differs in lightness, smell, consistence, and inflammability, in its several specimens. Authors have distinguished a considerable number of varieties: they have given the name of *naphtha* to the lightest, most transparent, and most inflammable petroleum; the name of *petroleum*, properly taken, is applied to a liquid bitumen, rather thick, and of a deep brown colour; and lastly, that of *mineral pitch* is used to denote a black thick bitumen, scarcely liquid, but tenacious, and sticking to the fingers. The following varieties are described by Wallerius, and many other naturalists.

Varieties.

1. White naphtha.

2. Red naphtha.

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3. Green, or dark-coloured naphtha.
4. Petroleum, mixed with earth.
5. Petroleum exuding from between stones.
6. Petroleum floating on the surface of waters.
7. Mineral pitch, or *Malta*.
8. Pissasphaltum. It is of a middle consistence, between that of common petroleum and asphaltos, or bitumen Judaicum.

The different naphthas are found in Italy, in the duchy of Modena, and at Mount Crocchio, twelve leagues from Plaisance. Kempfer reports, in his *Amenitates Exoticae*, that it is collected in large quantities in several parts of Persia. Petroleum is found in Sicily, and many other parts of Italy; in France, and the village of Gabian in Languedoc; in Alsace; at Neufchatel in Switzerland; in Scotland, &c. The pissasphaltum and mineral pitch were formerly brought from Babylon, where it was used in the construction of edifices; from Ragusa in Greece, and the Tank or Pond of Samoset, capital of Camogena, in Syria. It is at present obtained from the principality of Neufchatel and Wallengin; from the Well de la Pege, one league from Clermont-Ferrand in Auvergne; and several other places. It must be observed, with respect to the different varieties we have pointed out, that they all appear to have the same origin, and differ from each other only in some particular modification. Most naturalists and chemists attribute the formation of petroleum to the decomposition of solid bitumens by the action of subterraneous fires. They observe that naphtha appears to be the lightest oil, which is first disengaged by the fire; and that which succeeds it, acquiring colour and consistence, forms the different kinds of petroleum: that, lastly, these united to earthy substances, are altered by acids, and assume the characters of mineral pitch, or pissasphaltum. In support of these opinions, they have made a very accurate comparison between these phenomena, and those which the distillation of amber presents, which in fact affords a kind of naphtha, a petroleum more or less brown, according to the degree of heat, and time of the operation. And lastly, they observe that nature often presents in the same place other kinds of petroleum, from naphtha, the lightest, down to the mineral pitch: such are the fluid bitumens obtained from Mount Fes-

tin, in the duchy of Modena. Though this opinion is very probable, some authors think that petroleum is a mineral, oily combination, formed by the sulphuric acid and some fat substance; but this combination likewise would owe its origin to certain organic substances, since fat matters are always formed by such.

The chemical properties of petroleum have not yet been examined. Naphtha is so volatile and combustible, that it takes fire on the approach of any burning substance, and seems even to attract flame, on account of its volatility: the brown petroleum affords an acid phlegm, an oil, which at first resembles naphtha, and becomes more dense and coloured, in proportion as the distillation advances: a thick substance, resembling pissasphaltum, remains in the retort, which may be rendered dry and brittle, like asphaltos, and by a stronger fire is reduced entirely to the carbonaceous state. Alkalis have scarcely any action on petroleum; the sulphuric acid colours, and renders it thick; the nitric acid inflames it, like essential oils; it readily dissolves sulphur, becomes coloured by metallic oxyds, and unites, by the assistance of heat, to amber, which it partly softens, and partly dissolves.

The different species of petroleum are used for various purposes in the countries where they are obtained. Kempfer informs us, that they are used in Persia for the purpose of illumination, and burned in lamps with a wick; they may likewise be used as fuel. Lehman affirms, that naphtha is, for this purpose, poured on a few handfuls of earth, and afterwards lighted with paper: it immediately catches fire, and burns briskly; but at the same time emits a thick smoke, which sticks to the surrounding bodies, and has a very disagreeable smell: it has been thought that petroleum enters into the composition of the Greek fire; the thicker kind is likewise used as mortar for building, for which purpose it is very solid and durable. By decoction of pissasphaltos with water, an oil is obtained, which is used instead of tar for vessels.

Lastly, Some physicians use petroleum successfully in paralytic weaknesses, and disorders of the muscles, applying it externally to the skin, or exposing the diseased part to its smoke. Van Helmont asserts, that frictions with petroleum are an ex-

cellent remedy for frozen limbs, and recommends it as a good preservative against the impression of cold.

NOTES ON GENUS VI.

^a Succinic acid dissolves, in 24 parts of cold, and in 2 parts of boiling water. The solution affords, by evaporation, triangular prismatic crystals, the points of which are truncated. This acid is also more soluble in warm than in cold alcohol.

To purify succinic acid from the oil with which it is usually mixed, Lowitz directs 2 parts of the acid to be rubbed with 3 of boiling water. As soon as the acid is dissolved, one part of charcoal dust is to be added, and the mixture poured on a filtering cloth, which has been previously moistened, and covered with charcoal powder. The liquor which passes through the filter affords very pure and beautiful crystals. Any acid remaining on the filter may be dissolved by adding a fresh portion of warm water. *Crell's Annal.* 1793, B. I. f. 32.

With potash, succinic acid forms shining white transparent three sided prismatic crystals, which have their ends obliquely truncated. Succinat of potash deliquesces slightly in the air, dissolves readily in water, and has a bitter saline taste. It decrepitates on burning charcoal, and is decomposed in a strong heat.

Succinat of soda forms a salt which is obtained partly in three sided prismatic crystals, and partly in crystals which are foliated. It suffers no change in the air, has a bitterish taste, and dissolves readily in water. Like succinat of potash, this salt is also decomposed in the fire.

Succinat of ammoniac is obtained in small needle-shaped crystals, which have a saline bitter cooling taste. This salt is volatilized by heat, and deliquesces in the air. The fixed alkalis decompose it.

Succinat of lime shoots into long pointed crystals, which suffer no change in the air, and are difficultly soluble even in boiling water. The composition of this salt is destroyed in the fire. It is decomposed by the carbonat of ammoniac, but not by either of the caustic fixed alkalis. Lime-water, on the contrary, decomposes the succinat of potash and soda. Neither is the succinat of lime decomposed by the muriatic, nor by acetous acids.

Succinat of magnesia crystallizes, according to Richter. According to Wenzel, it forms a white mucilaginous frothy saline mass, which attracts moisture from the atmosphere. *Richter ueber die neuern. Gigenstands*, St. VI. f. 154.

Succinat of alumine affords crystals, which part readily with their acid in the fire. Alkalis and lime decompose this salt.

Barytes forms a salt very difficultly soluble in water with the succinic acid. This earth decomposes all the other succinats.

Succinic acid expels the carbonic acid from all its earthy and alkaline combinations.

Morveau melted 300 decigramms of nitrat of potash, and projected on it 15 decigramms of succinic acid. Detonation, with a slight flame, was produced.

The residue was saturated with nitric acid, and 240 centimetres of carbonic acid were collected in the receiver of a chemico-pneumatic apparatus.

Red vapours were disengaged by distilling succinic with nitric acid. A salt was formed by cooling, which in appearance resembled the oxalic acid, but which did not, like this acid, decompose the sulphat of lime.

77,2 centigramms of succinat of soda were introduced into a small retort, connected with a pneumatic apparatus. On applying heat, a little phlegm first passed over into the receiver, and afterwards a little brown oil. A small quantity of carbonic acid gas was disengaged at the same time, and a still larger quantity of carbonated hydrogen gas, which had a very strong empyreumatic oily smell. The alkali in the retort was in the state of a carbonat.

The liquor in the receiver reddened tincture of turnsole, and had the odour of empyreumatic acetous acid. Scheele had formerly remarked the smell of this acid in distilling succinic with the nitric acid. *An. de Chem.* Tom. XXX.

^b Mr. Hatchet, in a late paper on this subject, remarks, that many facts and observations concur to disprove this hypothesis; and that compact bitumens are often, if not always, formed from naphtha and petroleum. When naphtha is exposed to the air, it becomes at first yellow, afterwards brown, and in proportion as it thickens passes into petroleum. This substance has a greasy feel, is thicker than naphtha, transparent, and of a reddish or blackish brown colour. By exposure to the air it becomes like tar, and is then called mineral tar. This substance is viscid, and by exposure to the air passes into mountain or mineral pitch. If mineral pitch be broken in cold weather, it exhibits internally a glossy lustre. It is softened by warmth, and then possesses some tenacity. In a superior degree of induration, it becomes asphaltum, which is a light brittle substance of a brownish black colour. When broken, it shows a conchoidal fracture, with a glossy lustre; has little of a bituminous smell, unless when rubbed or heated. Asphaltum melts easily, is very inflammable, and, when pure, burns without leaving any ashes. In this manner, says Mr. Hatchet, naphtha, by inspissation, passes successively through different states, until it becomes asphaltum, which appears to be the ultimate degree of induration which the simple bituminous substances derived from naphtha can receive. See *Linnean Transactions*, Vol. IV.

^c Jet, according to Mr. Hatchet, is neither asphaltum nor coal, but a kind of intermediate substance, which may be regarded as the first gradation from the simple bitumens into those which are compound. Asphaltum undoubtedly enters into the composition of jet in a large proportion, but the extraneous or earthy matter with which this is mixed, gives to it the characters of coal. These characters are found more distinctly marked in the substance usually called Cannel Coal, which, from the great resemblance which it has to jet in many of its properties, seems to be the next gradation of the compound bituminous substances, and the leading variety of coal, from which the others follow, according to the degree of the bituminous character.

^d Pit-coals in general, according to Mr. Hatchet, appear to be composed of bitumen intimately mixed, or rather combined, with various proportions of carbon and earthy matter; and according to the intimacy of the union, and the excess of one or other of the ingredients, so the compound possesses more or less the characters of perfect coal; or by various shades passes into certain earthy or stoney substances, which, although impregnated with bitumen, do not merit the appellation of coal; and these also at length gradually lose the bituminous character. In this manner perfect pit-coal passes into schistose or slaty coal; and this again, by certain gradations, passes into the varieties of combustile or bituminous schistus;

which also, by the gradual decrease of the bituminous ingredient, become at length confounded with the varieties of the common or argillaceous schistus.

Mr. Kirwan, in an Appendix to the 2d volume of his *Elements of Mineralogy*, has given an analysis of different species of mineral coal and of bituminous substances, which cannot fail to prove highly interesting to the practical economist. This analysis will enable him to compare the various kinds of coal afforded by different countries, and to employ that which shall appear to him to be best suited to his intentions. The mode of ascertaining by combustion the quantity of carbonaceous matter contained in coal appearing to Mr. Kirwan to be liable to many objections, he endeavoured to ascertain this by the quantity of coal required to decompose a given quantity of nitre. From some experiments of Lavoisier, as corrected by Mr. Kirwan, it appears that 100 parts of nitre require for their decomposition 12,709 parts of pure charcoal. It had been long ago observed by Macquer, that nitre detonates with no oily inflammable matter till this matter be reduced to a coal, and then only in proportion to the quantity of carbonaceous matter it contains; and Mr. Kirwan in his experiments found that the carbonaceous part of the bitumen contained in coal, contributed so little to the decomposition of the nitre, as to merit no consideration in the general account.

Mr. Kirwan's method consists in projecting one or two grains of coal reduced to a coarse powder on nitre, heated barely to redness, and in preserving a uniform degree of heat during the combustion of these substances. From a great variety of experiments, conducted with every regard to accuracy, Mr. Kirwan has been enabled to draw up the following synoptical table of the contents of bitumens, and of different sorts of mineral coal.

100 Part.	Carbon.	Bitumens.	Ashes.	Spec. Grav.
Maltha,	8	—	—	2,070
Asphalt,	31	68	—	1,117
Kilkeny,	97.3	—	3.7	1,526
Compact Cannel,	75.2	21.68 Maltha,	3.1	1,232
Slaty Cannel,	47.62	32.52 Maltha,	20	1,426
Whitehaven,	57	41.3 mixt	1.7	1,257
Wigan,	61.73	36.7 mixt	1.57	1,268
Swansey,	73.53	23.14 mixt	3.33	1,357
Leitrim,	71.43	23.37 mixt	5.20	1,351
Newcastle,	58	40 mixt	—	1,271

To these results, Mr. Kirwan has added a few more taken from a *Treatise on Pit coal* by Signior Fabroni: It is only to be remarked, that the coals were all examined by distillation.

100 Parts.	Carbon.	Bitumen.	Ashes.	Spec. Grav.
Coals of Halles,	86	12	—	—
— of Tudertino,	25	75	—	—
— of Cortolla	45	43	12	1,403
— of Macinaia,	63	37	3	1,411
Stoney of ditto;	12.5	37.5	50	1,666
— of Mocaio,	32	35	33	1,403

These coals contained very little asphalt, but chiefly maltha.

Most coals afford ammoniac by distillation. Coals also afford an acid commonly the muriatic, or if pyritous, also the sulphuric, more rarely the succinic.

According to Jars, 100 parts of the best English coal give, when charred, 63 of coak, but Hielm found the residue of the best English coals distilled, to amount to 73 per cent. and Dr. Watson found the residue of Newcastle coal to amount only to 58 per cent. These results necessarily differ according to the degree of heat applied, the duration of the combustion, and the variable admission of air. It is plain, the bitumen is never totally expelled, at least not till most of the carbon, is consumed, but much more of it is expelled by combustion than by distillation.

ELEMENTS

OF

NATURAL HISTORY

AND OF

CHEMISTRY.

PART III.

THE VEGETABLE KINGDOM.

CHAPTER I.

CONCERNING THE STRUCTURE OF VEGETABLES.

VEGETABLES are organized bodies, fixed at the surface of the earth, and possessing neither sensibility nor spontaneous motion. They are distinguished by their external appearance and construction, and differ more particularly from minerals, in the circumstance of their being nourished by intromission, and their elaborating the juices designed to increase their bulk. They present phenomena, which depend on their organization, and are called functions; the principal of which is, their reproduction, by means of seed, or eggs, like animals.

Vegetables differ from each other, 1. By their magnitude: they are distinguished into trees, shrubs, herbs, mosses, &c. 2. By their places of growth: some grow in dry, and others in moist grounds; others in sand, clay, water, on the surface of stones, or on other vegetables, &c. 3. By their smell, taste,

colour, &c. 4. By their duration : plants are perennial, annual, biennial, &c. 5. By their use, either as food, medicine, &c. A great number are used in the arts, such as dying, &c. others are used merely for pleasure, ornament, &c.

Vegetables, externally considered, are formed of six parts, or organs, destined to perform peculiar functions. These parts are the root, the stem, the leaf, the flower, the fruit, and the seed. These differ in form, texture, magnitude, number, colour, duration, taste, &c.

1. The root is concealed in the earth, in water, or in the bark of other vegetables. It is either tuberous, or fibrous, or bulbous. Its direction is either perpendicular or horizontal ; and its consistence, as well as its form, is subject to great variations. Botanists distinguish them into several species, and avail themselves of these distinctions as specific characters.

2. The stem grows out of the root, and sustains the other parts. It is either solid or hollow, ligneous or herbaceous, round, square, triangular, or having two acute angles, &c. The stem comprehends the wood and the bark. The wood is distinguished into wood, properly so called, and *aubier*, or soft wood. The bark consists of the epidermis, the pulp or vesicular part, and the cortical strata, or inner rind. The stem is divided into branches, which have absolutely the same structure ; and the diversity of this part very often serves to establish the distinctive characters of the species and varieties.

3. The leaves of vegetables are exceedingly varied. A, By their form : they are oval, round, sagittate, hastate, oblong, elliptic, cuneiform, &c. B, By their position on their stem : they are either sessile, petiolate, opposite, alternate, stellate, perfoliate, vaginant, &c. C, By their margin : they are either uniform, dentate, crenate, serrate, repand, undulated, lacerated, truncated, &c. D, By their simplicity or composition : compound leaves are formed by the insertion of foliolæ, or lesser leaves, and are then either digitate or conjugate, with either an odd or an even number of leaves. E, By their position or place : they are radical, cauline, or floral. F, By their colour, smell, taste, consistence, &c. Their use appears to consist in absorbing the elastic fluids of the atmosphere by their inferior surface, and exhaling different kinds of air, according to circumstances, by their superior surface.

4. The flowers are parts designed to contain the organs of generation, and defend them till the fecundation is accomplished, at which time they fall. The flower is distinguished into two parts: the external part serves to enclose and protect the internal part, whose use consists in reproducing the plant. The former comprehends the calyx and the corolla. The calyx is external, and green. Linnæus distinguishes it into seven species, namely, the perianthium; the spatha, or sheath; the husk; the involucre; the amentum, or catkin; the calyptra, or veil; and the volva. The corolla is the coloured part, commonly called the flower: it is either monopetalous, consisting of one single piece; or polypetalous, consisting of several parts. The system of Tournefort is founded on the corolla. The parts of the corolla are called petals. The organs included, and often concealed in plants, are the stamina, and the pistils or styles. The stamina are the male, or fecundating parts, and are almost always more numerous than the pistils. They consist of the filaments and the anthera. This last, placed at the extremity of the filament, is a small bag, containing the fecundating power. The pistil is in the midst of the stamina: it is sometimes on another flower, or even on another plant; which circumstance occasions the distinction of plants into male and female. The pistil consists of three parts; the inferior part, which contains the embryo, and is called in Latin *germen*; the filament, which grows out of the inferior part, and is called the style; and its extremity, which is more or less dilated, is called *stigma*. The sexual system of Linnæus is founded on the number and position of the stamina and pistils. Jussieu has established a system, founded on the insertion of the stamina above or below the germen, &c.

5. Flowers are succeeded by fruits. Botanists distinguish seven species; the capsule, the silique, the legumen, the conceptaculum, which becomes dry; fruits having kernels, fruits having pippins and berries, which remain succulent. These organs are designed to enclose the seeds, and defend them from external agents.

6. The seed differs greatly in its form, magnitude, appendices, &c. It contains the plumula, or small plant; the radicle, and the cotyledons. These last are two in number in most

vegetables; but many families of plants have no more than one cotyledon. This part is to the grain what the yellow and white of the egg is to the embryo bird; it contains a proper nourishment for the individual during the germination. Besides the cotyledons, many seeds contain pulpy and farinaceous bodies, &c.

Vegetables, considered with respect to their internal parts, present five species of vessels, or organs, which exist in all their parts; 1. The common vessels, which conduct the sap: they are placed in the central part of plants and trees, and rise perpendicularly, though with lateral bendings, so as to form small vacancies between them. 2. The proper vessels, which convey the juices peculiar to each vegetable, such as the oils, gums, resins, &c. They are placed beneath the bark, and appear in many places to be dilated into cavities, or reservoirs, which seem to be the excretory vessels. 3. The tracheæ, or vessels through which the air vegetables receive from the atmosphere circulates: when a young green branch is torn asunder, they may be observed of a spiral form, resembling a cork-screw. They are often filled with sap. 4. The utricles, or small vessels, which contain a secreted juice, and frequently colouring matter. They are placed in the middle of the stem. 5. The vesicular tissue, which exhibits a series of small cells, which leading horizontally from the pith, and crossing the sap vessels, and filling the vacuities between them, are expanded beneath the epidermis, form a kind of soft covering, resembling the skins of animals. The vesicular tissue of vegetables appears to answer to the cellular membrane of animals.

All the parts of vegetables consist of an assemblage of these five kinds of vessels, each in particular being more or less numerous, dilated, contracted, &c. The differences in the form and texture of roots, stems, leaves, &c. depend on this diversity of number and disposition.

Malpighi, Grew, and Duhamel, have been the most successful in their researches into the natural history of plants, and their works are the most instructive, with respect to the internal formation of their several parts.

CHAPTER II.

THE NATURAL PHILOSOPHY OF VEGETABLES.

THE organs of vegetables, which we have concisely described in the foregoing chapter, are designed to perform several motions, which are called *functions*. These functions are,

1. The motion, or circulation of the fluids.
2. The alterations, or change of these fluids, by secretion.
3. The augmentation and developement of the vegetable by nutrition.
4. The exhalation of different fluids elaborated in the organs of vegetables, and the inhaling of several principles contained in the atmosphere, by the same organs.
5. The action of the air, and the use of this fluid in the vessels of vegetables.
6. The motion performed by some of their parts.
7. The kind of sensibility by which they endeavour to obtain the contact of such bodies as tend to promote the functions, such as light, &c.
8. And lastly, The various phenomena which serve to reproduce the species, and constitute the generation of plants. We shall consider each of these functions separately.

The principal fluid of vegetables, which is known by the name of *sap*, is contained in peculiar vessels, called the *common vessels*. These vessels, which are placed in the middle of the stem, and beneath the bark, are extended from the root to the leaves and flowers. The sap which they conduct, is a colourless fluid, of an insipid taste, and, like the blood in animals, becomes separated into different juices, for the nourishment and support of the several organs. It is very abundant in the spring, its presence being then shown by the production of leaves and flowers. All the phenomena of vegetation, as well as experiments made by applying ligatures about plants, show, that it rises from the root to the stem and branches.

But it is not so well ascertained, that it descends again towards the root, as some philosophers have affirmed. The valves admitted to exist, by many botanists, in the common vessels, have not been exhibited; unless we may call by this name certain fibres, or hairs, with which their internal parts appeared to be lined, according to Tournefort and Duhamel. The regular motion of this fluid is very far from resembling the circulation in animals.

The sap, when conveyed into the utricles, and thence into the proper vessels, is elaborated in a peculiar manner: it produces different saccharine, oily, mucilaginous fluids, which are emitted in consequence of an organic process, and whose evacuation seems to be an advantage to the vegetable, since it does not receive any damage from a very considerable occasional loss of those matters. This alteration of the fluids, which is very observable in many organs, as in the nectarium, at the extremity of the pistil, in the pulp of fruits, at the base of the calyces, and of many leaves, is produced entirely by that function, which in animals is called *secretion*. Guettard has carried this analogy so far, as to describe glands of various forms at the bases of the leaves of fruit trees, and towards the inner extremity of the petals of certain flowers. It is this secretion which develops the principle of smell, the colouring matter, the combustible substance, &c. But it differs very essentially from animal secretion, which is entirely produced by the organization of the glands, which elaborate the animal fluids; whereas, in vegetables, the juices contained in the common vessels are more exposed to the contact of air, light, and the action of heat; and their situation renders them capable of passing through the processes of fermentation by means of these agents.

The sap, while it remains in the cavities of the utricles, and of the vesicular tunic, becomes thick, and more consistent. This alteration renders it capable of adhering to the sides of the fibres, and of gradually augmenting their dimensions. Such is the mechanism of the nutrition of vegetables, their increase of magnitude, and the development of their parts. It greatly resembles the nutrition of animals. The vesicular tunic, and the utricles, have the same conformation, and the same use

in both classes of organized beings. In both, they penetrate all their organs, establishing an immediate communication between them, and in both they are the true seat of nutrition.

Philosophical botanists have long been convinced, that exhalations are emitted into the air from the surfaces of plants. The odoriferous exhalation of leaves and flowers forms an atmosphere around vegetables, which strikes our senses, and which the contact of a body on fire is sometimes capable of inflaming, as has been observed with regard to the fraxinella. This exhalation appears to be a peculiar kind of inflammable gas. Experience has likewise shown, that many vegetables emit vapours which are mortal to such animals as remain long exposed to them. Such are the yew, and many trees, natives of hot countries.

The experiments of Ingenhoufz have shown, that the leaves of all plants exposed to the light of the sun emit an invisible fluid, which consists of true vital air, similar to that which is obtained from oxyds of manganese, of mercury, &c. This property of leaves is entirely changed in the shade, in which situation they emit the carbonic acid. This happy discovery, first published by Dr. Priestley, shows an unsuspected property in plants, namely, that of purifying and renewing the air, by restoring that portion of vivifying fluid which is continually destroyed by combustion, respiration, &c. But at the same time that vegetables continually emit vaporous fluids produced in the last processes of vegetation, they likewise absorb many of the principles contained in the atmosphere. The lower surface of leaves absorbs the humidity of the dew, according to the experiments of Bonnet. Dr. Priestley's experiments likewise prove, that vegetables absorb the gases, which remain after combustion and respiration, and that vegetation is stronger in air changed by these processes. The exhalation and inhalation at the surface of vegetables are consequently much more considerable than was supposed before the time of the modern discoveries. It even appears that the water absorbed by the inferior surface of leaves is decomposed; that the hydrogen it contains is absorbed; and that the pure air disengaged from the superior surface of the leaves is produced by the oxygen contained in that fluid. The contact of the rays

of the sun contributes greatly to this decomposition, as it does not take place in the shade. Plants defended from the action of light, absorb water entirely without decomposition, and become white, insipid, and soft; a much less quantity of coloured, combustible, or oily matter, being formed.

The gases absorbed by vegetables, are conveyed into all their organs by the air vessels, known by the name of tracheæ, which in their use and structure resemble those of insects and worms. The air vessels are not, however, appropriated solely to the circulation of elastic fluids; for they are observed to be filled with sap, at those times of the year in which that fluid is most abundant; a circumstance which constitutes a great difference between them and the organs of respiration, so essential to the existence of a great number of animals. From the theory of respiration, which we have explained in the history of air, it is easy to show why the temperature of vegetables does not exceed that of the air which surrounds them.

It cannot be doubted, but that many parts of vegetables have an internal principle of motion; in some it is so evident, as to be most obviously distinguished. Such is the motion of the sensitive plant, of the stamina of the Indian fig, of pellitory, &c. This motion seems to depend on the function, which is known in animals by the name of *irritability*; for it is excited by the action of a stimulus, and has peculiar organs, which some botanists have compared to muscular fibres.

Ought we not to admit a sort of sensibility in plants, when we observe them to turn their leaves and flowers towards the sun, and when we observe that plants, enclosed in wooden boxes, glazed on one side, perforated, or merely thinner on one side than the others, constantly tend towards the transparent body, or the aperture through which the light passes, or even towards the side, which by its less thickness may admit a glimmering light? Or, may we not attribute this apparent sensibility to the force of affinity, or tendency to combination, which exists between vegetables with light? It is well established, that this fluid, either by percussion or combination, assists in producing the colour, taste, and combustible property in plants; because plants, which grow in the shade, are white, insipid, aqueous, and contain no inflammable matter; whereas vege-

tables exposed, in the burning climates of the south, to the strong rays of the sun, become highly coloured, abound with bitter and resinous parts, and are eminently combustible. However strong we may suppose this affinity to be, we cannot conceive how it should be capable of exciting a motion so considerable in the branches and leaves of vegetables. We must therefore necessarily admit a peculiar kind of sensation, or feeling, very different, it is true, from the senses of animals, by means of which vegetables give a preference to such situations as are most accessible to light.

The manner in which the species are produced, among vegetables, greatly resembles the generation of animals. The existence and union of sexes are necessary in the greatest number of plants. The labours of the celebrated Linnæus have discovered a strong analogy between the organs destined for this function in the two classes of organic beings. The stamina correspond with those of the male sex, and the pistil is composed of three parts, analogous to those of the genitals of female animals. The embryo is developed, by the action of the fecundating powder, without which it is not capable of producing an individual, as is likewise daily observed among birds. But besides this analogy, which need not be further pursued, vegetables are of a much simpler structure than animals; and all their parts being composed of the same organs, each is capable of producing a new individual similar to itself. This is the reason of the reproduction of plants, by means of scions or slips, as well as the alteration of the fluids, by grafting, whether natural or artificial. There is likewise another analogy, of modern discovery, between vegetables and that class of animals which is reproduced, by division into pieces, as the polypus, crustaceous insects, certain worms, &c.

All the functions, which, taken together, constitute the resemblance between vegetables and animals, are susceptible of alterations, which produce disorders. These depend, most commonly, on the abundance or defect of the sap, as well as its bad qualities, and are analogous to those which take place in animals. Their causes, symptoms, and cure, are alike referable to the general principles of medicine, and form a part of agriculture, which it must be confessed is not much advan-

ced, but capable of great improvement, according to the plans of several celebrated authors.

CHAPTER III.

CONCERNING JUICES AND EXTRACTS.

THE fluids contained in vegetables, are of two kinds; the common, and the proper juices. The first, consists of the sap which is found in all plants. This fluid seems to perform the function of the blood in vegetables. It is contained in the common vessels, flows naturally out of their surface, but is more abundantly extracted by incision. The sap is not merely an aqueous fluid, but contains salts, extracts, and mucilages. When a certain quantity is desired, either for medical use, or philosophical inquiry, the plant is beat in a mortar, and pressed in a cloth, beneath a press, if necessary.

Succulent vegetables give out their juice by simple expression; but those whose juices are viscous, or in small quantity, require to be diluted with water, such as borage, and the dry aromatic plants. This fluid being extracted, by strong pressure, is found to contain a portion of the solids of the vegetables beaten small by the pestle, and consequently requires depuration; which may be effected either, 1st, By subsidence, or filtration, when they are very fluid, as is the case with the juice of purslain, houseleek, &c. 2d, By white of egg, which collects the fecula, by coagulation, as is requisite with the juice of borage, nettle, &c. 3d, By simple heat, which coagulates and precipitates the parenchyma, as Baumé advises, with respect to juices that contain volatile principles, such as those of cochlearia, cresses, &c. The phial which contains the juice, being covered with a perforated paper, must be plunged in boiling water, and taken out as soon as the juice is clarified. Immersion in cold water brings it to a proper temperature for filtration. 4th, By spirit of wine, which coagulates the fecula. 5th, By vegetable acids, as the London Pharmacopœia prescribes for the juices of cruciform plants.

The juices of plants hold in solution matters which, when

separated from the aqueous vehicle, form what, in pharmacy, are called *extracts*. These are distinguished into three kinds; mucilaginous, saponaceous, extracto-resinous extracts.

Mucilaginous extracts, are such as readily dissolve in water, scarcely at all in spirits of wine, and undergo spirituous fermentation: such is the rob of gooseberries, prepared by evaporating the juice of that fruit.

Saponaceous extracts are distinguished by solubility in water, and partly in spirits of wine; they become mouldy, instead of passing to the spirituous fermentation. The juice of borage, when converted into an extract, is of this nature; and these are extracts properly so called.

Extracto-resinous extracts dissolve in water and in alcohol; they are inflammable, by virtue of the resinous principle they contain, and are not changed by exposure to air. The concentrated juice of wild cucumber, called *elaterium*, is of this kind. Incisions are made in the fruit; and the expressed juice being suffered to clarify, by repose, is evaporated to dryness on the water bath.

Extracts of these three different species are prepared, in the large way, by evaporating the juices of several plants. Such, among others, are,

1. The juice of acacia, imported from Egypt, where the fruit of this tree is mashed, pressed, and the juice exposed to evaporation by the sun's heat. The inspissated juice of sloes is prepared, in Germany, by a similar process, and sold under the same denomination.

2. That of hypocistis, which is made like the foregoing, with the fruits of this parasitical plant.

3. Opium, an important medicine, whose nature is not accurately known. It is extracted from the white poppy, in Persia, &c. where it flows through incisions made in the green capsules of the plant, in the form of a white juice, which dries into brown tears of the true opium. The opium of commerce is obtained, by pressure, from these capsules, moistened with water, and comes to us in a dry form, in flat circular cakes, wrapped up in leaves, and mixed with many impurities. It is purified by solution in as small a quantity of water as is sufficient to suspend it, with the aid of heat; which

being filtered, or strained by strong pressure, is evaporated on the water bath. This is the extract of opium, and contains a saponaceous extract, a resin, a solid essential oil, an odorous, noxious, and narcotic principle, an essential salt, and a glutinous matter. As the odorous, poisonous and narcotic principle is often productive of bad effects, attempts have been made to obtain an extract of opium deprived of this principle. Baumé, who has made many experiments on opium, volatilized this principle, together with the essential oil, and by that means separated the resin, after a digestion of six months. Bucquet has discovered, that the same sedative extract, without the narcotic property, may be obtained by dissolving opium in cold water, and evaporating the solution in a water bath. Lorry, who has made successful inquiries into this subject, finds, that opium, after fermentation, affords a distilled water, which had the sedative property, without producing the bad effects of the crude substance, and which he has used with great success. He observes, that the odorous principle of this medicine cannot be destroyed by any process.

When the plants, from which it is proposed to make extracts, are dry and ligneous, maceration, infusion, or decoction in water, are employed, according to the state and nature of the materials: maceration is, in most cases, sufficient. Odoriferous plants must be only infused; decoction extracts too much, and separates the resinous part, forming a thick fluid, which becomes turbid on cooling. Infusion may be used, in all cases, according to the opinion of the most celebrated physicians and chemists.

Water extracts various products from several plants. Thus the berries of juniper afford a mucilaginous extract; quinquina, a soapy extract, in small transparent scales, resembling salts, if the evaporation be made in very shallow vessels; and rhubarb affords an extracto-resinous substance.

The nature of the saponaceous, or more properly the chemical extract, was thought to be a compound of oil and fixed vegetable alkali. The extracts, prepared in pharmacy, are very far from being all of the same nature; they are mixed with mucilage, essential salt, saccharine juice, resin, &c. From these considerations, Rouelle, with the intention of illustrat-

ing this part of medical chemistry, distinguished them into the three genera we have mentioned: but the pure extract, reckoned among the immediate principles of vegetables, must be considered as a compound differing from the others, and possessing peculiar properties. I have found that this principle is by no means a soap; that it has the property of absorbing atmospheric oxygen; of becoming insoluble in water; and of assuming the characters of a concrete oil. These are the properties by which I now distinguish it from all the other immediate principles of vegetables.

Extracts are prepared in the large way, in commerce, by means of water. Such as,

1. The yellow juice of liquorice, by the first infusion, or black, by strong decoction. This last is burned, and contains a true charcoal. It is purified by solution in water, filtration, and evaporation, usually with the addition of some essential aromatic oil of anniseed, cinnamon, &c.

2. The caoutchouc is prepared in the East Indies from the infusion of the seeds of a kind of palm, called *areca*, the infusion being evaporated, and made into cakes. It is purified by solution in water, and evaporation, usually with the addition of aromatics.

Among the extracts prepared for medical use, Rouelle particularly distinguished those which are mixed with resin, by the names of *extracto-resinous*, and *resino-extractive* substances.

Extracto-resinous matter does not burn without being first dried, and appears to contain a larger quantity of extract, properly so called, than of resin. The resino-extractive burns much better, and appears to contain more resin, than extractive matter. This happy distinction shows, that the two species consist simply of mixtures of extract with different doses of the resinous principle. They are not, therefore, with propriety called extracts, that name being applicable only to the saponaceous matter, whose properties we shall proceed to enumerate.

The pure extract differs from the foregoing: it is a dry, solid, brownish red, transparent substance, which does not burn by itself, but emits plentiful fumes, and contains more or less essential salt. Its taste is almost always bitter; by di-

stillation, it affords an insipid phlegm; this phlegm, by a mild heat, becomes gradually of a deeper colour, and assumes alkaline properties, as is observable with elaterium, extract of borage, &c. The ammoniac is formed by the heat; a small quantity of empyreumatic oil next comes over; and the coal residue, which is light and porous, contains potash, and almost always neutral salt. The extract, exposed to air, becomes mouldy, and attracts moisture; the salt it contains crystallizing, and separating from the extractive part. They are often changed, and entirely decomposed. It dissolves in water; producing the appearance of a strong infusion. Acids decompose this solution, in the same manner as they do soaps, and disengage a principle more or less oleaginous. Metallic solutions likewise separate this principle, by double affinity. These properties were reckoned sufficient to make the extract be considered as a kind of soap; but they were owing chiefly to the attraction of this substance for oxygen, and the absorption of this principle. The extract, therefore, properly so called, is an organic compound of hydrogen, carbon, and a small quantity of azot, which has a strong attraction for oxygen, absorbs it from a great variety of bodies, and passes into the state of a concrete oil.

Extracts are used in medicine as aperitive, solvent, diuretic, stomachic remedies, and are daily administered with great success ^b.

NOTES ON CHAPTER III.

^a THE reader, before he begins to read this part of the text, will do well to consult the whole of Chapter X. in the *Philosophy of Chemistry*, together with the section on Chapter VII. entitled, *Acids of the Third Class, or with Binary Radicals*.

^b No part of chemistry has undergone of late years greater or more important changes, than that which relates to the analysis of vegetable substances. The method which has been followed in investigating the composition of vegetables, perhaps will be best understood by examples. Those which I shall subjoin have been taken from the writings of Fourcroy, or from those of his scholars and coadjutors.

Saps of vegetables. Vauquelin has lately examined these substances; and though from his analysis it appears that they differ considerably in their composition, yet there are principles in them which seem to be common to them all.

The sap of the common elm (*ulmus campestris*), collected early in Floreal, was of a red brown colour, had a mild mucilaginous taste, and reddened, in a manner scarcely perceptible, the tincture of turnsole. Ammoniac produced in it a very copious yellowish precipitate, which dissolved with effervescence in acids. The solutions of barytes and lime produced the same effect, Oxalic acid, and the nitrat of silver, produced a white precipitate. Sulphuric acid produced a lively effervescence, and the mixture emitted the smell of acetous acid. Oxygenated muriatic acid destroyed the colour of this sap, and produced in it a yellow coloured precipitate. The hydro-sulphure of potash, and sulphat of iron, produced no change. Alcohol occasioned a flocky precipitate.

1,039 kilograms of this sap were evaporated with a gentle heat. During the evaporation, 1. A brownish pellicle was formed at the surface; 2. A brown matter was separated in a flocculent form; 3. An earthy matter, rough to the touch, was deposited on the sides of the vessel. When 9-10ths of this liquor were evaporated, it deposited, in cooling, a yellow earth, which dissolved with effervescence in muriatic acid. The vegetable parts insoluble in this acid weighed 637 grammes. The muriatic solution, mixed with carbonat of potash, afforded 0,5 of carbonat of lime.

The remaining 0,1 of the liquor was filtered, to obtain the flocks which floated in it: these weighed 0,743 grammes, dissolved with effervescence in muriatic acid, and afforded 0,138 grammes of carbonat of lime, mixed with a little carbonat of magnesia. The carbonat of lime, therefore, had been mixed with 0,425 grammes of vegetable matter.

The liquor was now evaporated with a gentle heat. It afforded 9,553 grammes of a greyish extract, which strongly attracted moisture from the air, and had a very sharp saline taste. With concentrated sulphuric acid it produced a lively effervescence, and a smell similar to that of radical vinegar. When distilled with 3 parts of sulphuric acid, diluted with 2 parts of water, it afforded a very concentrated acetous acid. The residue in the retort was sulphat of potash, with an excess of acid. It follows, therefore, from these experiments, that the extract from the sap of the elm is chiefly composed of acetit of potash.

1,039 kilograms of elm sap contain 0,795 grammes of carbonat of lime, 1,06 grammes of vegetable matter, and 9,24 grammes of acetit of potash.

The sap of the elm collected later in Floreal, exhibited with reagents the same phenomena. During evaporation, a calcareous deposit was formed on the sides of the vessels, which dissolved with effervescence in acids. With carbonat of potash, this solution afforded 1,3 grammes of carbonat of lime, but to hold this quantity of carbonat of lime in solution, a quantity of carbonic acid is required, nearly equal to that which the carbonat itself contains. The liquor from which the calcareous carbonat had been separated, afforded 16,19 grammes of acetit of potash, and 2,069 grammes of vegetable matter. Remarking that the carbonat of lime, and the acetit of potash, did not exist in the same proportion in the wood and bark of the elm, as in the sap of that tree, Vauquelin is inclined to think, that these salts are decomposed by the vital actions of vegetables, and that the carbon and hydrogen in the acids of these salts, serve for the formation of vegetable matter.

Collected still later in the season, the sap of the elm did not differ from the foregoing in its physical properties, except in having a little more bitterness and

colour. By evaporation, it afforded the same products, but the quantity of vegetable matter was increased, while that of the carbonat and acetit was proportionally diminished.

The vegetable matter contained in the sap of the elm, when exposed to the combined action of air and heat, was changed in its colour, became insoluble in the sap, and was of course precipitated. From these properties, and from the vapours which it exhaled during combustion, it seemed to have passed from the mucilaginous state to that of wood, the particles of which not having had time to coalesce, remained in a pulverulent form.

The sap of the elm kept for some time in a flask, containing a small quantity of air, was completely decomposed and became alkaline.

2.45 hectogramms of this sap afforded, by evaporation, 16 grammes of brown flocks, which dissolved with effervescence in the nitric acid, by which it appears they consisted of carbonat of lime and vegetable matter. From the clear liquor evaporated to dryness, 0.106 grammes of carbonat of potash were obtained.

By this analysis, it appears that alkalis are not contained in vegetables in a state of combination with vegetable matter, but in the state of salts combined with the acetous and carbonic acids, and that their developement is owing to the destruction of the acetous acid. This analysis shows, that the sap of the elm is composed of acetit of potash, lime, a large quantity of vegetable matter and carbonat of lime. The sap of the elm contains also marks of the sulphat and muriat of potash, but they are too slight to be regarded.

Vauquelin takes advantage of these results to account for the origin of some very singular products in exudations, distilling from a kind of carious ulcer in some species of elm. In an analysis of this substance, contained in the 21st volume of the *Annales de Chimie*, he found that by washing 7 gros 46 grains of this exuded matter, which was of a white colour, with water, that the water acquired a slight amber colour and very evident alkaline taste, and gave now a green tinge to blue vegetable colours. When evaporated to dryness, it afforded by calcination in an open vessel, a brownish substance which weighed 1 ounce 5 gros 36 grains. This calcined matter was found to consist of carbonat of potash, mixed with a small quantity of the sulphat of potash.

The bark of the elm produced an effervescence in muriatic acid, and the solution afforded a copious precipitate by carbonat of potash, and oxalic acid. Lime water also produced a precipitate, but less copiously than either of the former reagents.

1000 parts of the bark of the elm seemed to be composed of

Vegetable matter,	-	0.605
Carbonat of potash,	-	0.342
Carbonat of lime,	-	0.050
Carbonat of magnesia,	-	0.003

A similar exudation of a black colour had also an alkaline taste, was soluble in water, effervesced with acids, and gave a green colour to blue vegetable infusions; alcohol coagulated it; acids decomposed it; calcareous and metallic salts decomposed it, and formed with it a very thick magma. Sulphuric acid formed a precipitate that was soluble only in a large quantity of water. Alkalis dissolved this deposit with great facility, and received from it a red colour. This substance seemed to owe its great solubility to the potash which it contained, and of which it was deprived by the acids. It seemed to have some properties analogous to the

gums. Like mucilage, it was soluble in water, and insoluble in alcohol, but it was precipitated from its solutions by acids which mucilage is not.

The quantity of potash obtained by combustion from 4 ounces 7 gros 46 grains of the bark of the elm, is equal to that obtained from 50 pounds of the wood.

The sap of the beech (*Fagus Sylvestris*) collected early in Floreal, had a brown red colour, and a taste similar to the infusion of tan. It reddened only very slightly the tincture of turnsole; a precipitate was formed in it by barytes, ammoniac, carbonat of potash, and oxalic acid. Oxygenated muriatic acid produced a flocky precipitate of a yellow colour. Concentrated sulphuric acid gave to it a black tinge, and disengaged a smell of acetous acid. The hydro-sulphure of ammoniac did not produce any change. Sulphat of iron was precipitated of a black colour; and the solution of glue formed in it a very copious white precipitate.

4,58 hectogramms of this sap evaporated with a gentle heat, afforded 10,508 grammes of a brown extract, very ductile in the heat, but brittle in the cold. The smell of this extract had a strong resemblance to that of warm bread; its taste also partook a little of that of bread. It strongly attracted moisture from the air, became soft, and at last liquid. Exposed to the air for 24 hours, it received an augmentation of 0,15 in its volume. Ammoniac was disengaged by adding quicklime to this extract. Sulphuric acid disengaged acetous acid. Alcohol dissolved only a part of this extract; a proof that it was of a mucilaginous nature.

The sap of the beech, therefore, is composed of, 1. A free acid; 2. A calcareous salt; 3. An alkaline salt; 4. Gallic acid; 5. Tannin; 6. An extractive and mucous substance.

The sap of the beech collected later in the season possessed the same physical and chemical characters with the foregoing.

9,171 hectogramms of this sap deposited by evaporation 0,796 grammes of a brownish matter, which by distillation afforded an ammoniacal product, a thick and fetid oil, and a carbonaceous residue, difficult of incineration. This charcoal, with muriatic acid, gave 0,26 grammes of alumine; the remainder weighed only 0,21 grammes.

The liquor from which this matter had been separated by evaporation, afforded, with a solution of fish glue, a greyish precipitate, which weighed 3,175 grammes. 100 parts of this combination, when dry, consisted of 43 of fish glue, and 57 of tannin. The liquor still contained gallic acid. It afforded, by evaporation, 18 grammes of an extract, only a small part of which was soluble in boiling alcohol, and the greater part even of this was deposited in the cold. The part insoluble in alcohol, when treated with water, left undissolved 0,530 grammes of a brown powder, which burned with difficulty, and which emitted during combustion the smell of animal matter; it remained black in the fire, and effervesced in a lively manner with muriatic acid, during which the carbon it contains was separated.

The liquor filtered and diluted with water, gave, with carbonat of potash, 0,372 grammes of carbonat of lime. It would seem, therefore, from this analysis, that the extractive matter possesses the property of decomposing calcareous acetar, in order to unite with its basis.

The solution in alcohol afforded, by evaporating it to dryness, a yellowish red transparent extract, which had a saline and sharp taste, attracted moisture strongly from the air, and had some resemblance to the mucous extract of farina. It was entirely soluble in water.

The aqueous solution of the extract insoluble in alcohol, mixed with a solution

of carbonat of potash, afforded 0,902 grammes of a coloured calcareous precipitate.

During evaporation, a pellicle was successively formed on the surface of the liquor, from which the precipitate had been separated. When reduced to dryness, nitric acid produced in it a lively effervescence, owing to the disengagement of carbonic and of acetous acids. When too large a quantity of nitric acid was added, the acid acted on the vegetable matter, and saccholactic and oxalic acids were formed.

It follows from this analysis, that the sap of the beech differs from that of the elm, 1. In the absence of the carbonat of lime; 2. In containing free acetous acid, tannin and gallic acid. It was natural to expect, that the sap of the beech should not contain any carbonat of lime, since it contained free acetous acid; yet it is possible that the calcareous salt may be produced in the vegetable by means of carbonic acid, and that the acetous acid may be afterwards formed, which, by combining with the lime, disengages the carbonic acid to be found in all saps. The sap of the beech contained also a colouring matter, which gave a red tinge to wool, cotton, and thread.

The sap of the yoke-elm (*carpinus sylvestris*), collected in the month of Germinal, was clear like water, had a slightly sweetish saccharine taste, and a smell similar to that of whey. It reddened strongly the tincture of turnsole. Barytes produced in it a very copious white precipitate, soluble in muriatic acid. Carbonat of potash also produced a white precipitate, which dissolved in acids with effervescence. Concentrated sulphuric acid gave a brown colour to this sap, and disengaged a strong smell of vinegar. Oxalic acid produced a copious white precipitate; and the nitrat of silver gave it a very beautiful red colour.

3,118 hectogrammes of this sap were distilled in a glass retort. A milky liquor passed over into the receiver: that which remained in the retort was of a brown red colour. This last afforded, by evaporation, 8,279 grammes of a straw-coloured extract, which had a sharp taste, attracted moisture slightly from the air, dissolved in water, and afforded, by alkalis, a yellowish white precipitate.

10,774 kilogrammes of the same sap were distilled in an alembic. The liquor which passed over was clear, and had a taste and smell very similar to that of whey. The first portions were not acid, but the last were very sensibly so. The residue was dry, had a brownish red colour, a sharp acid taste, and gave an evident red colour to turnsole.

This extractive residue was diluted with about 2,45 hectogrammes of water. A precipitate was formed; which consisted of a certain quantity of extractive matter, combined with the lime which had been separated from the acetous acid by the superior affinity of the vegetable matter.

The solution of extractive matter afforded a brown, transparent, brittle extract, which weighed 11,78 grammes. Exposed for 48 hours to the air, it became softened on its surface, and gained an additional weight of 2 grammes. Mixed with quicklime and a little water, it gave out a smell of ammoniac.

2 grammes of this extract dissolved in water, and mixed, 1. with muriat of barytes, formed a precipitate insoluble in muriatic acid; 2. with nitrat of silver, a deposit insoluble in nitric acid; 3. with sulphuric acid, a coloured flocky precipitate. 4. with oxalic acid, a white precipitate; 5. with ammoniac, a coloured light precipitate; 6. with carbonat of potash, a more copious and less coloured precipitate than the foregoing.

The sap of the yolk-elm was received in a copper vessel, which gave to it a green colour.

1,336 myriagrams of this were evaporated in a silver vessel. As soon as it began to boil, the green colour disappeared, and it became of a brown yellow. 2 grammes of yellow flocks were at the same time separated, which had no taste, but burned with a fetid ammoniacal odour. They were composed of oxyd of copper, and of a vegetable substance that had a strong resemblance to animal matters.

The liquor from which the flocks had been separated, when evaporated to dryness, afforded 12,7 grammes of a chestnut coloured extract, which was ductile and rosy when warm, but brittle when cold. Alcohol dissolved nearly one half of this extract; and the solution afforded, by evaporation, a transparent substance of a saccharine taste, which reddened the tincture of turnsole, and gave no precipitate with potash.

The matter insoluble in alcohol, when dissolved in water, let fall the oxyd of copper in the form of a red powder. The solution did not redden tincture of turnsole, but it gave a copious precipitate with potash. This extractive part swelled by heating it in a silver crucible, and emitted the smell of pyromucous acid, leaving behind it a reddish residue, consisting of carbonat of lime and red oxyd of copper.

It appears, therefore, from the evaporation of the sap of the yolk-elm, that the copper contained in it is reduced to the metallic state by the extractive matter which seizes upon its oxygen. It appears also, that alcohol separates this extract into two parts, one of which contains extract, sugar and acetit of potash, and another which contains mucilage, acetit of lime and a colouring substance.

1,957 kilogramms of this sap exposed in an open glass vessel exhibited the following appearances: 1. It became milky, while a kind of light scum formed on the surface; 2. Carbonic acid gas was continually disengaged; 3. It acquired the smell and taste of alcohol, and its acidity was increased; 4. At the end of some weeks this odour was dissipated, and carbonic acid was no longer disengaged; 5. Its acidity was still more increased, and the white matter which rendered it muddy was collected at the bottom in a flocky form; 6. At the end of 5 decades the acidity had diminished, and the liquor had become clear; a white mucilaginous pellicle had formed again on the surface, which increased in thickness; 7. This pellicle had diminished in its volume, and had assumed a blackish brown colour; the liquor was no longer acid, and had now a mouldy taste.

735 grammes of the same sap introduced into a bottle which contained 1,470 kilogramms, and which was accurately corked, exhibited some of the phenomena mentioned in the preceding experiment. It had become muddy, without becoming clear. The bottle was opened at the end of three months, and the air it contained was found to consist of azotic gas and carbonic acid. The liquor had a very strong taste of vinegar.

The sap of the birch (*betula alba*) has no colour; its taste is sweet, and slightly saccharine. It reddens strongly the tincture of turnsole. Ammoniac occasions no change in it. Barytes produces a precipitate, which is almost wholly soluble in muriatic acid. Alcohol does not produce any separation. Carbonat of potash produces a white light precipitate. Lime acts nearly in the same way as Barytes. Oxalic acid occasions a white deposition. Oxygenated muriatic acid produces no change. The concentrated sulphuric acid disengages vinegar. Nitrat of silver occasions a red colour. The hydro-sulphures, sulphat of iron, and fish glue, produce no change in this sap.

3,918 kilogramms of this sap were distilled in a glass retort; the liquor acquired a brown colour; what passed over was slightly milky. The liquor, reduced to

about one fourth of its mass, deposited, by cooling, 0,212 grammes of a red brown powder, which was insoluble in water. The liquor from which this powder had been separated was reduced to the state of a dry extract. This extract, which weighed 34 grammes, had a brown colour, attracted humidity from the air, had a very agreeable taste, and dissolved almost entirely in alcohol.

1,171 myriagrammes of the same sap were distilled in a sand bath to 306 grammes; the residue had a red brown colour, and a very considerable saccharine taste. In order to ascertain whether this residue would afford alcohol, 306 grammes were mixed with 122 grammes of water, and 15,5 grammes of the yeast of mild ale. The mixture was exposed to a temperature of from 12 to 15 degrees. At the end of some days, it showed all the marks of fermentation. When 15 days had elapsed, it was subjected to distillation, and 122 grammes of a liquor were obtained, containing a large proportion of alcohol. The liquid remaining in the retort had a red colour, a taste saccharine and slightly bitter, and the smell of beer. It reddened strongly blue vegetable colours. Distilled almost to dryness, it afforded about 122 grammes of very strong acetous acid.

Several fruitless attempts were made to obtain crystallized sugar from this liquid, which induced Vauquelin to think that the saccharine matter does not exist in the state of a true sugar in this sap.

The extract from the sap of the birch had a saccharine taste, a red brown colour, and a smell of acetous acid. It dissolved completely in alcohol, with the exception of a brown pulverulent insipid matter. This extract was equally soluble in water, and its solution exhibited the following characters. By continuing to boil it for a long time, its colour was rendered deeper, and a brown flocky precipitate was formed, which increased towards the end of the evaporation. This precipitate became pulverulent by drying. It had no taste, burned readily, and left behind it white ashes, which were merely calcareous earth mixed with a little alumine. Acids and alkalis decomposed this coloured calcareous substance. Ammoniac poured into a solution of this extract formed a brown precipitate. White woollen stuffs boiled in a solution of this extract acquired a brown colour, while the extract lost a great part of its colour. The addition of a little saturated sulphat of alumine renders the colour of the stuffs deeper, and in this case the liquor is almost entirely deprived of its colour.

These experiments prove, that the extract contained in the sap of the birch, like other saps, is a true colouring matter; 2. That this colouring matter, by the assistance of heat, takes calcareous earth and alumine from the acetous acid.

About 15,3 grammes of the sap of the chefnut were collected in Prairial. It had only a slightly bitter taste. Evaporated to dryness, it afforded a brown extract, in which, at the end of a month, many small needles of nitrat of potash were formed. The extractive part was not sensibly soluble in alcohol; it swelled much on burning coals, and emitted the fetid smell of animal matter. The part soluble in water afforded much nitrat of potash. The extractive part was not very soluble in alcohol, and seemed to be of a mucous nature. The quantity of this sap was too small to discover in it the acetit of potash. When diluted sulphuric acid, however, was poured on the salt obtained from this sap, a very sensible smell of acetous acid was produced; so that this sap, like the former, contains acetit of potash, and unquestionably a portion of lime.

Bark of St. Domingo.—Fourcroy, in his analysis of this bark, the most complete model of vegetable analysis which has yet been exhibited to the world, obtained from one pound, by boiling it successively with 320 lbs. of water,

9 ounces 56 grains of a matter which could be separated, by means of alcohol, into

	Ounces.	Gros.	Grains.
1. A substance soluble in alcohol,	7	0	44
2. Mucilage,	1	1	—
3. A red powder,	0	2	—
4. Matter of a saline appearance,	0	1	—
5. Flocks insoluble in water,	0	1	12
Loss,	0	3	—

1. The mucilage possessed the well known characters of this substance. It afforded no ammoniac by distillation.

2. The crystallized saline matter had no well marked taste. It did not combine with alcohol, but was soluble in the proportion of 3 grains in 2 ounces of boiling water. Lime water produced on it no immediate effect, but after some days, a brownish precipitate was formed. Liquid caustic alkalis united to it with rapidity. By distillation, it afforded ammoniac, a yellow phlegm, hydrogen gas and carbonic acid, and oil with a voluminous carbonaceous residue.

3. The flocky matter precipitated from the solution in alcohol by water became soft on burning charcoal, and exhaled a very fetid white smoke. It was partially soluble in alcohol, but not at all in boiling water. By distillation, it gave out elastic fluids; a very fetid yellow liquor, which gave a green tinge to blue vegetable colours; a thick red oil, with a voluminous carbonaceous residue.

4. Red powder, papers tinged with this resisted the action of the air and of oxygenated muriatic acid, almost as long as Indigo. It combined neither with water, nor alcohol in any degree of temperature. Alkaline substances dissolved it very readily, and formed with it a brown red solution. By distillation, much oil, ammoniac, and a little water, were obtained; only a small quantity of elastic fluids or carbon.

5. The substance soluble in alcohol was of a red brown colour, taste very bitter, insoluble in cold, but soluble in warm water, according to the degree of temperature. In proportion as the water cools, the greater part is deposited, but a quantity equal to 1-24th of the water remains dissolved. Lime water added to this solution produces a reddish precipitate resembling ochre, which is redissolved, if much water be used. Acids seemed to produce no change in this solution. 1 gros of this insoluble matter put into 8 ounces of boiling lime water afforded a brick-like precipitate, insoluble in 500 parts of water, and in fixed alkalis. Alcohol dissolved it completely. This matter dried easily in the air, became black, brittle, and shining, like aloes. Distilled, it gave much hydrogen gas and carbonic acid, a liquid acid product with ammoniac, or the pyromucic of ammoniac with excess of acid. This principle appeared to Fourcroy to be similar to the resino-extractive matter of Rouelle. Oxygenated muriatic acid gas was introduced into a solution of 1 gros of this resino-extractive substance in 12 ounces of water. The first portions of the gas gave to the solution a clear red colour, and separated from it flocks of the same colour. The liquor and flocks gradually changed their colour, the first became almost white, the latter of a slight yellow colour; more of the acid heightened the colour of the flocks and destroyed that of the liquor. The flocks collected weighed 30 grains, were insoluble in alcohol at 25°, but easily so at 39°, and in alkaline liquors; lime water produced no precipitate; during evaporation the liquor deposited 15 grains of a black powder, and by continuing this evaporation to dryness 6 grains more, 4 of which were soluble in water. The soluble

part contained muriatic acid. It had, as well as the black matter, a sharp and rough taste. During the evaporation, a portion of the matter is precipitated in the form of true carbon.

If the operation be stopped when the red flocks begin to be precipitated, these flocks collected and dried, appear to resemble the red powder obtained from the cold decoction. If the operation be carried farther, the flocks become yellow, melt in boiling water, and collect at the surface of this fluid into a blackish layer or a true resin.

If a solution of this resino-extractive substance be exposed to the air, the surface comes in time to be covered with a beautiful red pellicle; if we stir the vessel, this pellicle is precipitated in a pulverulent form, possessing all the properties of the red colouring matter from the decoction. It is not converted into the yellow resin in this process. From these experiments, Fourcroy concludes, 1. That the bitter brown substance, called resino-extractive, differs from the red powder only in containing less oxygen; and, 2. That the addition of oxygen converts the red powder into resin, taking from it, at the same time, its taste and colour.

From the combustion of the 9 ounces 56 grains of the entire extract from a pound of bark, 2 gros of ashes were obtained. 64 grains of these were dissolved by treating them with 2 ounces of water. By evaporation, 4 grains of carbonat of lime were obtained, and 60 grains of a white salt, which had an alkaline taste. By adding acetous acid, a slight effervescence was produced. Evaporating to dryness and adding alcohol, 18 grains of acetit of potash were obtained. The salt remaining weighed only 50 grains. By muriat of barytes it was found, that this salt consisted of 12 grains of sulphat of potash, and 38 of the muriat of potash. The 80 grains remaining after the action of the water were treated with muriatic acid, the whole was dissolved, a lively effervescence produced, and muriat of lime formed. It appears that the lime existed in the quinquina pure, and not in the state of a carbonat, for acids took it from the extract without producing any effervescence. The 2 gros of ashes, therefore, contained

Potash,	10 grains
Sulphat of potash,	12
Muriat of potash,	38
Lime,	84

144 grains.

The residue from the decoction of the quinquina was without taste and of a reddish brown colour. Alcohol assumed, by boiling on this residue, a greenish colour, and water separated from the alcohol, a white matter resembling the gluten of corn.

Alkalis had a more marked action on this residue, becoming red, and the particles of the quinquina transparent, and as it were gelatinous. After the action of successive leys, a pound of this residue weighed only 3 ounces 6 gros 48 grains. The part dissolved seemed to differ little from that which remained undissolved. Acids separated it almost pure.

To the 6 ounces 1 gros 38 grains of residue from the decoction of one pound of bark diluted muriatic acid was added, a slight effervescence was produced, and by the assistance of heat, 193 cubic inches of carbonic acid gas were obtained. The muriatic solution afforded by carbonat of potash 4 gros 4 grains of carbonat of lime.

A pound of the residue was put into a retort and distilled in a heat gradually increased. 3200 cubic inches of elastic fluids passed over into the apparatus,

1600 of which were carbonic acid, and the remainder was carbonated hydrogen gas. 4 ounces 2 gros of a yellow liquor were contained in the receiver, which had the smell of pyro-mucous acid, reddened blue vegetable colours, and contained a large quantity of ammoniac, 1 ounce 64 grains of a brown concrete oil, the greater part of which was soluble in alcohol. The carbonaceous residue effervesced with acids, and contained lime.

A pound of the residue from the decoction was mixed with 16 pounds of water. After some time, it became reddish from the absorption of oxygen. A similar colour was produced the moment nitric acid was brought into contact with this residue, and the mixture became covered with froth from the disengagement of an elastic fluid. The solid and liquid matter became gradually yellow. Of the 504 cubic inches of gas disengaged, 336 were carbonic acid, the other 168 cubic inches were azot. The carbonic acid in this experiment, seemed to come from the carbonate of lime, for the disengagement was unaccompanied with the production of nitrous gas. By applying heat, this gas was produced in great abundance. Boiled for a quarter of an hour, the liquor and the residue assumed a citron colour; after being washed and dried it weighed 5 ounces 1 gros. By the evaporation of the liquid, 1 ounce 5 gros 22 grains of oxalate of lime was obtained. By a third evaporation, crystals of oxalic acid were deposited, which were separated from the other saline matter by the addition of lime. By adding to the liquor, still farther evaporated, a solution of nitrate of lead, 1 gros 36 grains of a yellow substance were deposited, which, on examination, proved to be the malate of lead. By saturating the liquor with potash, and evaporating to dryness 1 gros of acetate of potash was found in the residue.

The crystals of oxalate of lime and the precipitate weighing 10 ounces 3 gros, were treated with diluted muriatic acid, a slight effervescence was produced, and the saline mass lost 1 ounce 3 gros. The muriatic solution evaporated to the consistence of syrup, had an acid taste, though it exhaled no more vapours of muriatic acid. Lime water was poured into the solution, and 1 ounce of citrate of lime obtained. The 9 ounces remaining undissolved were oxalate of lime. From 1 pound of residue were obtained by nitric acid,

	Ounces.	Gros.	Grains.
1. Carbonic acid,	0	4	48
2. Azotic gas,	0	1	8
3. Lime,	0	6	—
4. Oxalic acid,	9	0	—
5. Citric acid,	0	5	—
6. Malic acid,	0	0	36
7. Acetous acid,	0	0	45
	11	1	65

The residue well washed and dried, weighed 5 ounces 1 gros. It had a citron yellow colour and an austere taste, was insoluble in water, but very soluble in alkalis, which deepened its colours. By heating a part of it with concentrated nitric acid, it afforded the same products as in the foregoing experiment. Distilled in close vessels, it afforded much concrete oil, carbonated hydrogen gas, carbonic acid gas, pyroligneous and sebaceous acids, but not one particle of ammoniac, the nitric acid having disengaged the azot, as in its action on animal substances.

A pound of quinquina reduced to powder was distilled in a chemico-pneumatic apparatus, to which 3 receivers were adapted, containing each 2 pounds of lime water. At first a colourless, then yellowish fluid passed over into the receiver. Carbonic acid gas was disengaged before any inflammable gas. The latter gas was accompanied by a brown concrete oil. By this process, 3000 cubic inches of elastic fluids were obtained, 5 ounces of a yellow and fetid water, and 2 ounces of concrete oil. The carbonaceous residue weighed 5 ounces 50 grains. The precipitate in the flasks of lime water weighed 3 ounces 1 gros 8 grains, and contained 1 ounce 8 grains of carbonic acid. Muriatic acid disengaged from the carbonaceous residue, as much carbonic acid as 230 grains of lime require for the production of calcareous carbonat.

The products from the distillation of this pound, therefore, were,

	Ounces.	Gros.	Grains.
1. Phlegm,	5	0	—
2. Oil,	2	0	—
3. Carbon,	4	2	38
4. Calcareous carbonat,	0	6	2
5. Carbonic acid,	1	0	8

Had the 3000 cubic inches of elastic fluid been pure hydrogen gas, it would have weighed 1 gros 53 grains, but it was united to carbon which diminished its volume and made it weigh more.

The phlegm had the smell of pyrolignous acid and reddened blue vegetable colours. It appeared from experiments to be a mixture of pyromucit and pyrolignit of ammoniac, with an excess of pyromucous acid. Lime forms with the pyrolignous acid, a crystallizable very insoluble salt, with the pyromucous acid, a salt soluble in alcohol and deliquescent. In this process, it is difficult to ascertain the quantity of water, as well as of oxygen. Some of the hydrogen escapes in the form of gas, some in that of oil, and some in acids. The quantity of azot seems to be most easily ascertained from that of the ammoniac which lime disengages.

A pound of quinquina burned with a slight flame, afforded 7 gros of ashes, of which cold water dissolved 60 grains, 10 grains carbonat of potash, 12 grains sulphat of potash, and 38 grains of muriat of potash. The residue dissolved with effervescence in muriatic acid, all except 4 grains which seemed to be filix, from the sides of the furnace. By adding sulphuric acid to the evaporated solution, a sulphat of lime weighing 1 ounce 1 gros 11 grains was obtained. During the solution, 143 grains of carbonic acid were evolved. Lime water produced a precipitate of 20 grains of calcareous phosphat. There is, therefore, 15 ounces 1 gros of matter in a pound of quinquina, reducible into elastic fluids and liquids by heat, and these fluids and liquids consist of hydrogen, carbon, azot, and oxygen, combined together in a proportion not easily ascertained.

Red Bark.—Fourcroy infused an ounce of the red Peruvian bark for some days in 8 ounces of water. It gave to the water only a very slight degree of colour. This infusion became mouldy at the end of some days, and appeared to contain a mucous substance. It reddened blue vegetable colours, precipitated lime water, decomposed sulphat of iron, and emitted a sensible odour of ammoniac. The bark itself had lost only a few grains.

An ounce of this bark was boiled at 7 different times in 14 pounds of water. The decoction at first was of an orange red colour, but became afterwards clear

and transparent. During the evaporation of this decoction, grains of different figures, and very solid, appeared on the surface of the liquor. The matter which was separated by evaporation was very light, and was precipitated with difficulty. When three-fourths had been evaporated, it was allowed to cool, and the colouring substance, now separated, of a chestnut red colour. The liquor had only a slight orange tinge. It was evaporated a second time, till about only 2 ounces remained. In cooling, some more grains of colouring matter were separated. The liquor was evaporated a third time to dryness; and the products of the different evaporations being mixed, they weighed 38 grains. Half an ounce of distilled water, digested for some hours on this product, reddened blue vegetable infusions, but did not form any precipitate with the muriat of barytes. It gave a black colour, at the end of some hours, to a crystal of sulphat of iron; it precipitated lime water of a yellowish white colour. Lime disengaged a smell of ammoniac. A portion of this matter evaporated to dryness, gave out vapours of muriatic acid, on adding to it the sulphuric acid. Carbonat of potash, and oxalic acid, produced white precipitates in the solution of this substance. These experiments show, that the decoction of red bark contains, 1. Citric acid; 2. Ammoniacal muriat; 3. Muriat of lime. By comparing, therefore, the action of boiling water on this species of bark, with that which it has on the bark of St. Domingo, it will be found, 1. That the decoction of the Peruvian bark is not mucilaginous, does not mould and swell up, like that of St. Domingo; 2. That the extractive matter, and what is separated by evaporation and cooling, forms only 1-16th of the Peruvian bark. It differs from that of St. Domingo in not being precipitated in a ropy matter, but in a chestnut brown coloured powder; its taste is less bitter, but more astringent; it dissolves neither in warm water nor alcohol. By analyzing it, we separate neither gum, gluten, matter of a saline appearance, nor the coloured and insoluble powder separable from the bark of St. Domingo. It seems, however, to be analogous to that powder.

The residue, from the decoction with water, was boiled with 12 ounces of alcohol, from which, by evaporation, 24 grains of a red matter, resembling some oxyds of iron, and insoluble in water, were separated.

The 7 gros of residue were boiled in 12 ounces of a caustic solution of soda. Only 1 gros 51 grains remained undissolved. The residue had acquired a kind of transparency and gelatinous appearance, had no taste, and its colour was brown. The portion dissolved in alkali had acquired a reddish colour, and was separated by acids under the form of a mucilage of the same colour, which dissolved readily in warm water. This kind of mucilage, subjected to distillation, afforded the same products with the entire extract, except that it seemed to give less ammoniac.

From these experiments it appears, that the Peruvian bark exhausted by water differs from that of St. Domingo in its colouring principle, as well as in the resinous-extractive matter which alcohol takes from it. This principle seems to be the same with that which is taken from it by water, but modified so as to be no longer soluble in that liquid; a property it probably derives from a quantity of oxygen which has been fixed in it.

The residue, completely exhausted by water and alcohol, resembled in every particular the same residue from the bark of St. Domingo. It afforded the same products in distillation, the same acids with the nitric acid, and was equally soluble in alkalis. The ligneous base seems to be the same in all dry vegetable substances.

1 gros 4 grains of ashes were obtained from the combustion of 6 ounces of the red bark. Dissolved in 4 ounces of distilled water, 18 grains of a saline substance

were obtained from the ashes, composed of 11 grains of carbonat of potash, 4 grains of muriat of potash, and 3 grains of fulphat of potash. The remaining 54 grains united readily with the muriatic acid. Sulphuric acid formed in this solution 1 gros 12 grains of fulphat of lime. Lime-water added to the solution separated 5 grains of pure magnesia.

From these experiments it appears, that the Peruvian bark does not afford so much ashes as that of St. Domingo, since a pound of the latter affords 7 gros, while the same quantity of the former affords only 2 gros. The ashes, however, of the Peruvian bark contain more saline matter; for 76 grains of the ashes from the Peruvian bark afford 18 grains of salt, while 7 gros of the other gives only 54 grains. *Ann. de Chem.* Tom. VIII. p. 113. Tom. IX. p. 7.

Peruvian bark (*cinchona officinalis*).—An ounce of this was infused for 40 hours in 24 ounces of water, at 12° of Reaumur. The mixture became mouldy. The water had become yellow, bitter, saline, and somewhat astringent to the taste. By evaporating it to 3 ounces, it formed, in cooling, a deposit, which weighed 5 grains. The bark had lost 30 grains. The residue was boiled repeatedly in water till it no longer gave any colour or taste to this fluid. When united and evaporated slowly to 6 ounces, these decoctions afforded, by cooling, a reddish precipitate, weighing 28 grains. By carrying on the evaporation to 2 ounces, a similar red powder was precipitated. This liquor afforded 2 gros 16 grains of an extractive substance. This mass boiled with 3 ounces of alcohol, imparted to it a reddish colour; by cooling, 20 grains of nitrat of potash were deposited on the sides of the vessel.

Slowly evaporated, the spirituous mixture exhibited red layers, which, when dry, weighed 6 grains, of which one and a half was magnesia. The muriatic acid had been carried off along with the alcohol. The other 4 grains seemed to be of the same nature with that deposited from the decoction. The mass remaining was mucilaginous. It dissolved in 2 ounces of water, and afforded 4 grains more of the precipitate. Carbonat of potash precipitated from it four and a half grains of carbonat of lime, mixed with a half grain of alumine. By boiling, another grain of magnesia and 6 grains of muriat of potash were obtained.

To the united decoctions of an ounce of bark, lime water was added, so long as any precipitate was formed. This precipitate was of a red colour, and weighed 6 grains. The mass was dissolved in 3 ounces of water, and, in filtering, left 10 grains of a pulverulent residue on the filter. The solution did not now produce any black precipitate in mixing it with the solution of fulphat of iron. Carbonat of potash was added to the solution, and a white earth was precipitated, weighing 6 grains. With sulphuric acid, this earth afforded 6 grains of fulphat of lime and alumine. By boiling the residue with 3 ounces of alcohol, 20 grains of nitrat of potash were obtained by cooling, and 6 grains of muriat of potash by evaporation. In this process the lime takes the astringent principle from the decoction of bark, and decomposes the muriat of magnesia. Boiling water, therefore, extracts from an ounce of bark

Nitrat of potash,	20 grains.
Muriat of lime,	6
Magnesia,	4
Alumine,	1 1-half.
Mucilage,	60
Reddish powder,	40

131 1-half grains

Cold water dissolves little of the reddish powder. It was on this principle that the property of producing black precipitates with the sulphat of iron seemed to depend.

The extract, 3 gros 4 grains from an ounce of bark, burned in a crucible, was reduced to a charcoal, weighing 66 grains. Evaporating from it 4 ounces of water, 16 grains of a saline substance, giving a green tinge to blue colours, were obtained. By treating it successively with diluted sulphuric acid, alcohol, and muriatic acid, it appeared that the extract from an ounce of bark contained carbonat of potash, 3 grains; muriat of potash, 6 grains; carbonat of lime, 3 grains; magnesia, 2 1-half; alumine, 4 1-half; = 19 grains. *C. C. Berthollet. Ann. de Chem. Tom. XVI. p. 172.*

Senna.—Bouillon Lagrange obtained an extractive matter from the evaporation of the decoction and infusion of senna. Oxygenated muriatic acid produced the same effect on this extractive matter as on the infusion or decoction. This extract, in close vessels, gave much hydrogen gas and carbonic acid, with a liquid and an oily product. The liquid contained ammoniac and pyromucous acid, for it reddened blue vegetable colours, and exhaled ammoniac by the addition of lime.

Alcohol dissolves about one third of this extract. Water produces no change on the solution. Evaporated to dryness, a dry, friable, bitter mass is obtained, which attracts moisture from the atmosphere. Mineral acids dissolve it. Alkalis produced a yellow precipitate in the solution in alcohol, which seems to resemble much that obtained by the addition of oxygen.

Distilled water dissolves the part not dissolved by alcohol. Alcohol, lime water, and alkalis, produce no precipitate in the aqueous solution. By evaporation, it affords a bitter brown matter, soluble in water, but not in alcohol. This forms an adipocere by the addition of oxygen.

The aqueous solution precipitates barytes; not so the alcoholic solution.

A yellowish brown precipitate is formed by exposing an infusion of senna for some time to the air, upon which water seems to have little action. It appears to take from it a little colouring matter and lime.

Alcohol dissolves a portion. If this solution be evaporated, we obtain a blackish scaly bitter mass, which has all the properties of a resin. Subjected to distillation, a liquid acid, concrete oil and carbonic acid are obtained. The liquid acid contained ammoniac. These results are the same as from the substance obtained by means of oxygenated muriatic acid.

By combustion, the dry extract affords potash, sulphat of potash, carbonat of lime, magnesia, and filix.

With nitric acid senna leaves afforded the oxalic acid.

By distillation, senna affords a coloured acid liquor, carbonic acid, a brown concrete oil, and hydrogen gas, with a carbonaceous residue. Muriatic acid occasioned an effervescence with this residue, disengaged sulphurated hydrogen, and produced the muriat of lime.

It appears from this analysis that the part dissolved by alcohol is not a resin, but a substance containing the principles of resin, and requiring only oxygen to form one. *Ann. de Chem. Tom. XXIV. p. 14.*

Cassia fistularis.—Vauquelin has given an interesting analysis of this substance in the 6th volume of the *Annales de Chemie.*

An extract of 6 ounces 7 gros were obtained from a pound of that substance, by treating it with 6 pounds of warm water, and by separating the insoluble parts with the filter.

During the evaporation of the liquor, an elastic brown pellicle was successively formed and removed. It weighed when dry 73 grains.

When reduced to 1-4th of its original volume, two substances separated by cooling, one soft and slightly solid, weighing when dry 4 gros; the other liquid.

A new evaporation did not occasion any similar separation. Alcohol separated a very black matter, weighing two gros. By evaporation, the alcoholic solution afforded two ounces of a yellowish transparent matter, which had at first an agreeable, but, after some time, a nauseous taste. By treating the residue of the extractive matter with oxygenated muriatic acid, 47 grains of a yellow precipitate were obtained. By saturating the muriatic acid arising from the decomposition of the oxygenated acid, the liquor gave a slightly coloured substance, which had a very agreeable taste.

When the oxygenated muriatic acid was added in too large a proportion, it acted on the saccharine principle, and gave rise to new properties. This action was prevented by adding a little ammoniac. The quantity of saccharine matter obtained was equal to 2 ounces 3 gros.

Examination by reagents.—The *seeds* swelled in boiling water, broke their coverings, and assumed a mucilaginous form. The plantule had undergone none of these changes.

The *parenchymatous matter* was of a black colour, without smell or taste. Alcohol had no action. The nitric acid forms oxalic acid with it, disengaging at the same time azot. Oxygenated muriatic acid bleaches it.

The *brownish pellicle* was insoluble in water, but soluble in spirit of wine. The solution was decomposed by water. Nitric acid disengages from it a small quantity of azot, and the residue is almost pure oxalic acid. Caustic alkalis unite to it with heat. It is analogous to the gluten of corn.

The *soft and slightly solid matter* dissolved only in small quantities in cold, but readily in warm water. This combination congealed by cooling; taste bitterish; united easily to alkalis; nitric acid formed with it oxalic acid, with the disengagement of azot. Oxygenated muriatic acid destroyed its bitter taste, which was owing to the action it had on the colouring matter. This substance is chiefly gelatin.

The *matter evaporated by the alcohol* had a bitter taste, and deep brown colour. It at first attracted humidity from the air, but afterwards became dry and brittle. It united with water, and exhibited all the characters of a mucilage. Nitric acid changed it into the oxalic, and oxygenated muriatic acid into the citric acid. It became mouldy, and was decomposed in the air.

The *matter separated by oxygenated muriatic acid from the alcoholic solution* had different colours, according to the quantity of acid employed; with a small quantity of acid it became reddish, with a less yellow or brown. This was the pure extractive matter, when uncombined with the oxygenated muriatic acid. Lime water, by uniting with it, separates it from the other principles of the cassia. It is in this way that the lime acts in purifying sugar, and by saturating the malic acid which exists in molasses. This matter acquires new properties by combining it with oxygenated muriatic acid. 1. It is rendered insoluble in water. 2. It unites more easily with fixed and volatile oils. 3. Alcohol dissolves it like a resin. 4. Alkalis combine with it readily, and give to it a deep red colour, though it was formerly yellow.

The *matter separated by adding the oxyd of silver*, had only a slight citron colour, and a saccharine agreeable taste. It dissolved in water and in alcohol; nitric acid changed into oxalic acid; oxygenated muriatic acid into one resembling the citric. This substance was almost pure sugar.

By heat.—The *parenchyma* strongly heated, gave out much hydrogen gas and carbonic acid; then a liquid slightly acid, which exhaled a great quantity of ammoniac by lime. This was pyromucit of ammoniac with excess of acid. A small portion of oil also was obtained. The carbonaceous residue was not alkaline.

The *substance analogous to gluten* gave much carbonated hydrogen gas and carbonic acid. Its phlegm gave a green tinge to blue vegetable colours. Lime showed the presence of an alkaline carbonat. Its oil was copious, and its carbon a little alkaline. The odour in distillation similar to that of animal matters.

From the *gelatinous substance*, besides the elastic fluids common to all vegetables, much pyromucous acid was obtained, very little oil, and almost no ammoniac.

From the *mucilage*, no ammoniac, very little oil, and a large quantity of pyromucous acid.

From the *extractive matter separated by the oxygenated muriatic acid*, much thick oil and muriatic acid, of a singular odour, with very little carbon, were obtained.

From the *saccharine substance*, by oxyd of silver, nearly the same products as from the mucilage, but a greater quantity of oil. A pound of the pulp of cassia appears to be composed of

	Ounces.	Gros.	Grains.
Parenchyma,	0	3	—
Gluten,	0	1	1
Gelatin,	0	4	—
Gum,	0	2	—
Extract,	0	0	47
Sugar,	2	3	—
Valves,	5	5	—
Seeds,	2	1	—
Partitions,	1	1	0
Water,	3	3	24

By combustion.—100 grains of *parenchyma* afforded 6 grains of ashes, containing 3-4ths of a grain of carbonat of potash, 1-half of a grain of fulphat of potash, 3-4ths of muriat of potash, 2 grains of carbonat of lime, 1 grain of alumine, 1-half grain of oxyd of iron, and 1-half grain of filex.

400 grains of *gelatinous substance* gave only 8 grains of ashes, containing 2-1 half grains of carbonat of potash, 3 1-4th of calcareous carbonat, 1 1-half of alumine, and 3-4ths of oxyd of iron.

600 grains of the *partitions*, or *septa*, afforded 16 grains of a residue, containing 9 1-half of carbonat of lime, 5 grains of fulphat of lime, 1 grain of alumine, 1-half grain of iron, and 1-4th of filex. There was no alkali nor alkaline salt in this substance.

8 ounces of *cassia wood* gave 1 gros of ashes, containing 20 grains of carbonat of potash, 5 1-4th grains of muriat of potash, 3 grains of fulphat of lime, 7 grains of fulphat of potash, 32 grains of carbonat of lime, 2 grains of oxyd of iron, 2 grains of alumine, and 3-4ths grains of filex.

The same substances were formed, but in different proportions, in the ashes of the sugar, gum and extract. The quantity of ashes from these substances varied according to the degree of heat, and the time taken up in burning them. When the ashes were kept red hot, for instance, for some hours, they contained no alkali, though another portion of the same substance afforded a large quantity in a lower degree of heat.

The alumine, filix, and a portion of iron, came from the crucibles in which these substances were burned.

The proportion of these parts varied in different specimens of cassia. In some species, Vauquelin found traces of tartaric and acetous acids. In some copper, from the vessels in which they had been prepared.

Tamarinds.—Vauquelin's analysis of the fruit of the tamarinds, exhibits also a very good example of the method of obtaining some of the acid bodies which naturally exist in vegetables.

Experiment I. Four ounces of the pulp of tamarinds were macerated for several hours in 8 ounces of cold distilled water, the liquor was then passed through a linen cloth, and about one half of it evaporated. During cooling, it deposited some white slightly acid crystals, which were but slightly soluble in water, and entirely insoluble in alcohol. After being dried, these crystals weighed 12 grains.

Experiment II. A few drops of a solution of potash were added to the liquor, evaporated to about 1-4th of its volume, 45 grains of a saline matter were separated similar to that obtained by evaporation and cooling. It proved on examination, to be the acidulous tartaric of potash, or cream of tartar.

Experiment III. Carbonat of lime, or chalk in powder, was now boiled with the liquor which was still acid. An effervescence took place, and a considerable deposit was formed. This precipitate was boiled for some minutes in about 1-4th of its weight of sulphuric acid diluted with 6 parts of water. The liquor was filtered and subjected to evaporation. In proportion as the evaporation went on, some particles of sulphat of lime were separated which had been held in solution by the acid disengaged from the lime by the sulphuric acid. The liquor reduced to a small volume, was converted into a mass of white irregular crystals, which dissolved readily in water. A precipitate was formed in this solution by lime water, but none by oxalic acid, muriat of barytes, or potash. From these properties, it became obvious that it was the citric acid which existed in the tamarinds, and which had been separated by the chalk. It weighed 3 gros.

Experiment IV. As papers tinged with blue vegetable colours did not discover any mark of acidity in the liquor in which the chalk had formed a precipitate, it was evaporated. During this operation, a substance was separated which had a saline appearance without taste, and of the same nature with the deposit from which the sulphuric had disengaged the citric acid. Potash forming a precipitate in this liquor, it was imagined that it contained a salt with a base of lime. In order, therefore, to discover the nature of the acid, a solution of acetit of lead was added, which produced a deposit weighing 27 grains. By treating this deposit with sulphuric acid, about 10 grains of malic acid were obtained.

Experiment V. By adding alcohol to this liquor, thickened to the consistence of a syrup, a considerable quantity of a greyish, viscid, and tenacious matter was separated, which exhibited all the characters of a mucilage, and weighed, when dry, 1 gros and a half.

Experiment VI. Some drops of oxalic acid were added to the liquor to precipitate the lime which had been disengaged from the malic by the acetous acid. When filtered, the liquor had an orange red colour, a very marked saccharine taste, but which left in the mouth a nauseous and bitter taste. It was evaporated to dryness, during which, it emitted the smell of vinegar. The residue slightly dried, weighed 4 gros, and exhibited all the properties of sugar.

Simple maceration by water takes, therefore, from the pulps of the tamarind:

1. mucilage; 2. sugar; 3. pure tartarous acid; 4. acidulous tartaric of potash; 5. citric acid; and, 6. malic acid.

Decoction.—Four ounces of the tamarinds which had been macerated in the cold water, were boiled in 8 ounces of water for a quarter of an hour, and the liquor was then strained and left to cool. Several hours after it was converted into a brown trembling mass which separated into two parts, one of which a liquid, occupied the lower part, the other, which was soft, semitransparent, and of a gelatinous appearance, floated on the former.

The gelatinous matter dissolved only in very small quantity in cold water, but it dissolved entirely in boiling water, and the solution assumed again the gelatinous appearance on being exposed to cold. By boiling, however, for a long time, it lost this property and seemed to approach to the nature of ordinary mucilage. When dry, it weighed 2 gros.

The liquor from which the gelatinous matter had been separated, deposited 63 grains of acidulous tartaric of potash, by reducing it to about 1-4th of its volume. Evaporated still farther, and mixed with alcohol, it deposited 10 grains of a mucilaginous substance.

The residue of the 4 ounces of tamarinds successively subjected to the action of cold and warm water, ceased at length to colour the water in which it was boiled, and weighed now, when dry, only an ounce and a half. From the united results of these experiments, Vauquelin concludes, that a pound of the pulp of tamarinds consists of

	Ounces.	Gros.	Grains.
1. Acidulous tartaric of potash,	0	4	12
2. Gum,	0	6	—
3. Sugar,	2	0	—
4. Gelatin,	1	0	—
5. Citric acid,	1	4	—
6. Disengaged tartarous acid,	0	2	—
7. Malic,	0	0	48
8. Feculent matter,	5	0	—
9. And lastly water,	5	6	52
	—	—	—
In all,	16	0	0

CHAPTER IV.

OF THE ESSENTIAL SALTS OF VEGETABLES IN GENERAL, AND
OF THOSE WHICH ARE ANALOGOUS TO MINERAL SALTS IN PAR-
TICULAR.

THE saline substances, held in solution in the juices of plants or the water wherein they are infused, are called *essential salts* of plants. They are obtained by cooling those fluids, which are first evaporated to the consistence of syrup. As these salts are impregnated with extractive and fat matter, it is necessary to purify them with lime and whites of eggs. If these salts be of an acid nature, lime must not be used, because it would neutralize them, but pure white clay in powder. After the first extraction, they are still very impure. Solution in distilled water, and crystallization, may be repeated till they become pure and white.

This process cannot take place, except with regard to such crystallizable essential salts as exist, ready formed, in vegetables. But vegetable salts have been discovered which are not crystallizable; some of which cannot be extracted but by more complicated processes, because of their mixture or combination with other principles. In order to know all the salts which vegetables contain or afford, we think it proper to distinguish them into six genera.

The first contains vegetable salts analogous to those of the mineral kingdom.

The second contains the pure acids of plants.

In the third, we shall place such acid salts as are combined with a certain quantity of potash, and we shall distinguish them by the names of *acidules*.

The fourth genus will include those which are formed by action of the nitric acid upon certain vegetable matters.

The fifth will be composed of those which owe their formation to heat.

And lastly, the sixth genus will be appropriated to such acids as are developed by a particular fermentation.

First Genus of Vegetable Salts. Salts analogous to those of the Mineral Kingdom.

The first genus of the essential salts of vegetables comprehends the neutral salts analogous to those of the mineral kingdom, which are extracted from their juices. The principal species are, 1. Fixed alkalis combined with carbonic acid, which are obtained from almost all plants, by macerating them with acids, as Margraaff and Rouelle the younger have shown. Potash is the most common, but soda exists in marine plants. 2. Sulphat of potash, in millefoil, in astringent and aromatic plants, in spurge flax, and in the mark of olives. 3. Sulphat of soda, from tamarisk and rotten wood. 4. Nitre, from borage, turnsole, tobacco, &c. 5. The muriat of potash: and marine salt, or muriat of soda, in marine plants. 6. Sulphat of lime, discovered by Model in rhubarb. The existence of this last salt is doubtful; for Scheele suspects that Model mistook the calcareous oxalat, or combination of the saccharine acid with lime, for sulphat of lime.

Many other salts will doubtless be found, resembling those of minerals, when a greater number of plants shall be accurately analyzed. It has likewise been thought that ammoniacal carbonat exists ready formed in cruciferous plants; because these plants, by distillation, afford, on the first application of heat, a phlegm which holds a small quantity of that salt in solution. On this account the ancients called them *animal plants*; but Rouelle the younger has shown, that this salt does not exist ready formed in plants, but is produced by the reaction of the principles, which is promoted by heat. Baumé pretended that the volatile principle of cruciferous plants is nothing but sulphur. The ammoniac obtained from these plants, arises from the hydrogen of the oil united to the azot contained in the vegetable, as Berthollet has shown.

Various opinions have been held, respecting the mineral salts found in plants. Some have thought, that these salts were conducted from the earth by water, and passed into the vegetables without alteration. Others have supposed, that the saline substances were formed by the process of vegetation. It is certain, that two very different plants growing in the

same soil, as, for example, borage and millefoil, afford each the salt peculiar to itself; that is to say, the borage affords nitre, and the millefoil sulphat of potash. A single experiment, which has been much talked of, but never accurately made, would decide the question; namely, to cause such plants as afford a certain salt, for example, nitre, to grow in a quantity of earth, previously lixiviated, and to water them with water containing muriat of soda or some other salt. If the plants in these circumstances afford nitre, and not muriat of soda, it might be concluded that the salt does not pass as such into the organs of the plants, and that the proper salt is formed by the process of vegetation. Whatever might be the result of this experiment, it will be shown, that several salts which we have examined in the mineral kingdom, such as the potash, the carbonic acid, and perhaps several others, are immediately formed in vegetables.

CHAPTER V.

OF THE SECOND GENUS OF ESSENTIAL SALTS, OR THE PURE ACIDS OF VEGETABLES.

WE arrange, in the second genus of vegetable essential salts, those acids which are ready formed, and are extracted in a state of purity, by very simple processes. There are four acids of this kind, namely, the citric acid, the gallic acid, the malic acid, and the benzoic acid.

§ 1. *Of the Citric Acid.*

We call by the name of the citric acid, that pure acid which Scheele obtained from the juice of lemons.

The chemists formerly, without attending to the peculiar characters presented by this acid juice, compared it to that of tartar; and, at that time, all the vegetable acids appeared to be of the same nature. Attempts had been made to concentrate and purify the acid juice of lemons and of oranges, in order to preserve them during long voyages. The juice of the former of these fruits has a taste so strongly acid, and it alters most blue colours so efficaciously, that its nature cannot

be doubted. Morveau has found, that the specific gravity of this juice is to distilled water as 1,060 to 1.

When this expressed juice is kept, it becomes turbid, assumes a disagreeable taste, and becomes covered with mouldiness; this alteration depends on a very abundant mucilage it contains, which the chemists have endeavoured to deprive it of. Before other methods were contrived, it was preserved in glass bottles, beneath a thin covering of oil. Some persons have proposed to put sand in the vessels, others added a mineral acid: these two last processes manifestly altered its nature; the first method was preferable to them, though, even in that situation, the juice, at the end of some days, contracted a sharp, oily, and disagreeable taste. Mr. Georgius has published, in the Acts of the Academy of Stockholm in 1774, a process to concentrate the juice of lemons, and render it unalterable. He directs that the lemon-juice should be kept for some time in a cellar in bottles laid down, in order to separate part of the mucilage, and afterwards to expose it to a cold of three or four degrees below 0 on the thermometer of Reaumur: the aqueous part freezes, and takes with it, as it appears, a portion of the mucilaginous matter. Care must be taken to separate the ice from the liquid, in proportion as it is formed: and the congelation must be continued until the ice which is formed becomes acid. Mr. Georgius has found, that when the juice is reduced to one-eighth of its volume, it is eight times stronger than before. A quantity of juice of lemon, which saturated thirty-six grains of potash in the ounce, saturated the same quantity of alkali, excepting one dram, after having been concentrated by frost. This acid, thus concentrated, may be employed in all domestic uses, or a dry lemonade may be made with it, by mixing it with six parts of refined sugar in powder.

Lemon-juice recently expressed, and exposed for some hours to the air, at the temperature of above 15 degrees of Reaumur, deposits a white, semi-transparent, mucilaginous matter, of a gelatinous consistence: when this juice is decanted and filtered, it is much less alterable than before. The dried, mucilaginous substance does not dissolve in boiling water; when treated with the acid of nitre, it affords azotic gas, and be-

comes converted into oxalic acid: it is not a gummy mucilage, but has an analogy with the vegetable gluten, of which we shall speak at the article flour.

Dubuiffon has preserved lemon-juice by an opposite process to that of Mr. Georgius. By evaporating this juice in a gentle heat long continued, the mucilage thickens, and is separated in the form of a crust or scum, and glutinous flocks; the liquid acid is concentrated, and may be preserved a long time without alteration in bottles well closed. Dubuiffon has observed, that the contact of the air which remains between the cork and the surface of this acid liquor concentrated by evaporation, is sufficient to separate, in the course of some weeks, flocks of a white substance, which he supposes to be glutinous, and which are collected together at the surface, where they form a coherent elastic body. The acid is not sensibly altered during this separation.

Such are the various processes which have been proposed and used before the time of Scheele, to purify and preserve lemon-juice. Although they prove that chemists had employed themselves upon this acid, yet it was not made, except for the uses of pharmacy; and the persuasion that its nature was analogous to that of the acid of tartar was such, that it had never been called in question. Stahl had asserted that lemon-juice, saturated with crabs eyes or chalk, assumed the nature of vinegar. Several chemists had attempted to combine it with alkalis, and had not been able to obtain permanent crystals from these combinations, doubtless on account of the mucilage with which it is so abundantly mixed. Morveau assures us, nevertheless, that, after having saturated the carbonat of potash, or mild vegetable alkali, with lemon-juice, the solution, exposed to the air, and filtered several times, afforded him a crystallized salt in small opaque grains which were not deliquescent.

Scheele has given, in Crell's Chemical Journal for 1784, a process for obtaining the acid of lemon in a state of greater purity, separated from the mucilage and extractive matter, which alter this fruit in the expressed juice, and under a concrete form: alcohol, which he at first used to separate the mucilage by coagulation, did not succeed; for after having filtered the

thickened fluid, evaporation did not afford crystals. He availed himself of the process he had discovered several years before, to purify the tartareous acid, and he succeeded in obtaining the pure citric acid in a concrete state. The following is the process: Boiling lemon-juice was saturated with powdered chalk; the acid formed with the chalk a salt of difficult solubility, and the supernatant water retained in solution the mucilaginous and extractive substances; the precipitate was washed with warm water until the fluid came off colourless: it is nearly as soluble in water as the sulphat of lime; it was afterwards treated with the quantity of sulphuric acid necessary for the saturation of the dose of chalk employed, and diluted with ten parts of water: this mixture was boiled for several minutes. After cooling, it was filtered; the sulphat of lime remained on the filtre, and the evaporated liquid afforded a concrete and crystallized acid. In this operation, it is better, according to the remark of Scheele, that there should be an excess of sulphuric acid, than to leave a small quantity of lime, which prevents the citric acid from crystallizing: the excess of sulphuric acid remains in the mother water^a.

The citric acid thus prepared is very pure and concentrated; its taste is strongly acid, and it reddens all the blue vegetable colours which are capable of that change. Fire decomposes and converts it into an acidulous phlegm, gaseous carbonic acid, and carbonated hydrogenous gas; a small portion of charcoal remains in the retort: its crystals are not altered in the air^b; it is very soluble in water, and its solution is decomposed by a true putrefaction, which is very slow. United with earths and alkalis, it forms the citrats of alumine, of barytes, of magnesia, of lime, of potash, of soda, and of ammoniac, whose properties have not yet been well ascertained, but which are known to be different from all other neutral salts^c. The nitric acid does not convert it into oxalic acid, as it does several other vegetable acids^d; it seems to be one of the most powerful of these acids; it acts on several metallic substances by the assistance of water, and notably on zinc, iron, copper, &c.

Its affinities, pointed out by Bergman, are in the following order: Lime, barytes, magnesia, potash, soda, ammoniac. Bersefey of Dijon has determined its attractions somewhat different-

ly: according to him, barytes holds the first rank, lime the second, and magnesia the third; the alkalis come afterwards. It follows, from the researches of these two observers, that the three alkaline earths are preferred to alkalis by this acid.

The uses of the citric acid are sufficiently numerous. With water and sugar it forms a very agreeable drink, known under the name of *lemonade*. It is employed in medicine as refreshing, cooling, antiseptic, antiscorbutic, diuretic; more particularly it corrects acrid bile. It is sometimes used as a slight escharotic in scorbutic ulcers, darts eruptions, and spots on the skin. When concentrated by the process of Mr. Georgius, or Dubuiffon, it may be used in sea voyages, and will be a great resource in remote expeditions of this kind.

§ 2. Of the Gallic Acid.

We give the name of *gallic acid* to that extracted from the nut-gall, which grows on the oak by the puncture of an insect. This acid exists in general in greater or less quantities, in all austere vegetable, or astringent substances: such are the woods of the oak, the ash, the willow, the barks of the same trees, the quinquina, fimarouba, pomegranate, fumach, tormentilla; the nuts of cypress; the husks of nuts; the stem and leaves of the marsh iris, the strawberry plant, the nenuphar, &c.

Chemists were formerly acquainted in this substance, which they distinguished by the name of *astringent principle*, with no other property than that of precipitating the solutions of iron in acids of a black colour, or of forming ink, which, indeed, is an exclusive and very characteristic property. Macquer, Monnet, Lewis, Cartheuser, and Gioanetti, made experimental inquiries into the mode of action of this principle upon iron. Monnet had more particularly remarked, that the nut-gall and astringent vegetable juices acted immediately on iron, and gave it a black colour. Gioanetti had observed, that the precipitate, or atramentary fecula, was not attracted by the magnet, and that the iron was not in the metallic state, as had been supposed before his time. These observations ought to have led to the notion that the astringent principle of the nut-gall was an acid, or at least that it acted as an acid in che-

mical operations. The academicians of Dijon are, however, the first who, after the above mentioned authors, began to perceive in their experiments that the astringent principle was an acid. These learned men have shown, 1. That the product of the nut-gall by distillation blackened the solution of sulphat of iron. 2. That one ounce of this excrescence affords a tincture to cold water, from which $3\frac{1}{2}$ drams of extract are obtained by evaporation. 3. That this infusion reddens turnsole and blue paper. 4. That the same principle is soluble in oils, in alcohol, and in ether. 5. That the acids dissolve it without altering it, and without depriving it of the property of precipitating iron of a black colour. 6. That this solution in water precipitates alkaline sulphures. 7. That it completely decomposes all metallic solutions, and colours their oxyds at the same time that it combines with them. 8. Lastly, that it dissolves iron in the direct way, and reduces silver and gold, after having separated them from their solvents. Such are the important facts announced by the academicians of Dijon, several of which were, indeed, before perceived by some chemists, but were not considered by any of them as indications of the acidity of this principle, excepting by these philosophers ^a.

Since their time, Scheele has not only shown that all austere and astringent plants exhibit signs of acidity, but he has likewise discovered and described a process to obtain this vegetable, pure and crystallized.

Six pounds of distilled water are poured upon one pound of nut-galls in powder; this is left to macerate during fifteen days, at the temperature of between 16 and 20 degrees of Reaumur; it is then filtrated, and the fluid is left in a tureen of stone ware, or a large glass capsule. It is suffered to evaporate slowly by exposure to the air. A mouldiness and thick pellicle is formed, which appears as if glutinous; very abundant mucilaginous flocks fall down; the solution then no longer possesses a very astringent taste, but is very sensibly acid; and after two or three months exposure to the air, a brown crust is observed adhering to the sides of the vessels, and covered with granulated, brilliant, yellowish, grey crystals; the same crystals likewise exist in large quantities beneath the thick pellicle which covers the liquor: the fluid is then decanted, and alco-

hol is poured on the deposit of pellicle and of crystalline crust, and heated. This solvent takes up the whole of the crystallized salt, but does not touch the mucilage: By evaporation of this spirituous solution, the pure gallic acid is obtained in small granulated crystals, of a brilliant appearance, and slightly yellowish grey colour ^b.

The gallic acid, thus purified, has a sour and slightly astringent taste: it precipitates the sulphat, and all other salts of iron, in a very beautiful and bright black ^c; it strongly reddens the tincture of turnsole; heated with the contact of air, it swells up and takes fire, emitting a somewhat agreeable smell, and leaves a charcoal of difficult incineration. When distilled by a gentle heat, part rises, dissolved in the water of crystallization; another part rises in small silky crystals, without decomposition; a strong fire separates some drops of oil, carbonic acid gas, and carbonated hydrogen. The nut-gall, distilled in substance, affords a small quantity of concrete salt, analagous to the sublimed gallic acid.

The gallic acid requires 24 parts of cold water, but no more than three of boiling water to dissolve it: repeated solutions and crystallizations do not render it sensibly whiter. Alcohol dissolves it much more effectually; four parts of this liquid are sufficient when cold, but when boiling it is soluble in an equal weight of that fluid.

This acid disengages the carbonic acid from earthy and alkaline bases, when its action is assisted by heat.

With barytes, magnesia, and lime, it forms salts, soluble in water, more especially by the assistance of an excess of these bases. Potash, soda, and ammoniac, unite very readily with it, and form gallats, whose properties are not yet known.

The nitric acid converts the gallic acid into the oxalic acid.

The gallic acid precipitates gold from its solvent in the form of a brown powder, and part of the metal appears at the surface in a brilliant and metallic pellicle. Silver is precipitated of a brown colour, and a film of this metal reduced, soon covers the surface of the liquor. Mercury is precipitated of an orange yellow; copper of a brown colour; iron of a beautiful bright black; and bismuth of a yellow lemon colour. The so-

lutions of platina, zink, tin, cobalt, and manganese, are not altered by this acid ^d.

Such are the properties discovered by Scheele in the gallic acid, prepared as has been described above : they are sufficient to cause this salt to be considered as a peculiar acid, different from all others. Its intimate nature, and the proportion of its principles, have not yet been determined. Morveau has obtained from it a resin, which he supposes to be the acidifiable base, whose union with oxygen forms this acid.

The uses of the nut-gall for dying black are sufficiently known. We shall only add, to what we have already said at the article of Iron, that, by employing the purified gallic acid for the preparation of ink, this fluid is very beautiful, very black, and may be kept a long time without alteration ^e.

§ 3. *Of the Malic Acid.*

We give the name of *malic acid* to a peculiar vegetable acid which Scheele extracted from the juice of several fruits, and which he found more particularly abundant in apples.

To obtain this acid, the juice of four apples is expressed, and saturated with vegetable alkali : to this liquor a solution of acetit of lead, or sugar of Saturn, is added ; a double decomposition takes place, the acetous acid combines with the potash, and the malic acid with the oxyd of lead ; the metallic salt, or malat of lead, falls down : this precipitate is washed and treated with the sulphuric acid, diluted with water ; sulphat of lead is formed, and the malic acid remains in the liquor. It is necessary to add a sufficient quantity of sulphuric acid to decompose the whole of the malat of lead, which is known by the fresh acid taste of the liquor.

This acid possesses the following properties : It cannot be obtained in the concrete form. With the three alkalis, it forms deliquescent neutral salts. With lime it forms a salt which affords small irregular crystals, soluble in boiling water, in vinegar, and in the malic acid itself. With clay it forms a salt of very difficult solubility. With magnesia, a deliquescent salt. It dissolves iron ; and this solution is brown, and does not afford crystals. With zink, which it dissolves well, it affords a salt in very fine crystals. The nitric acid changes it

into the oxalic acid. It precipitates the nitrats of mercury, of lead, of silver, or of gold, in the metallic state. The calcareous malat decomposes the ammoniacal citrat, and calcareous citrat is formed, which is insoluble in boiling water and in the vegetable acids. The solution of calcareous malat in water is precipitated by alcohol. Lastly, the malic acid is readily destroyed by fire, which changes it into the carbonic acid: this last partly saturates the bases of the malats, which are decomposed by heat. These are the properties which establish the peculiar characters of this acid.

Scheele found it almost pure, or mixed with a small quantity of citric acid, in the juice of apples, barberries, elderberries, floes, the fruit of the service-tree, and damsons. He found it in combination with half its weight of citric acid in gooseberries, cherries, strawberries, raspberries, and blackberries. And, lastly, he obtained it from sugar by the nitric acid; and Morveau remarks, that the malic acid appears before the oxalic acid.

When four fruits contain, at the same time, the citric acid and the malic acid, the following is the process which Scheele has followed to separate them, and to obtain the latter in a state of purity. The juice of gooseberries, saturated with chalk, affords calcareous citrat, which falls down because insoluble; the supernatant liquor holds in solution the calcareous malat, which is separated by alcohol: but as it still remains in combination with a portion of mucilage, Scheele had recourse to another method to obtain it pure. He evaporated the juice of gooseberries to the consistence of syrup, upon which he poured alcohol, which dissolved the acid without touching the mucilage, and he separated the latter by the filtre; the liquor being filtrated, he evaporated the alcohol, and saturated the acids with chalk: the portion of citric acid was precipitated in the form of calcareous nitrat, and the calcareous malat remained dissolved. This new alcohol precipitated it from its solvent, and Scheele obtained the malic acid by dissolving this salt in water, precipitating this solution by the acetit of lead, and by decomposing the malat of lead by the sulphuric acid. The malic acid was disengaged in the supernatant liquor.

§ 4. *Of the Benzoic Acid.*

It has been known, since the time of Blaise de Vigenere, who wrote at the commencement of the last century, that benjamin affords, by distillation, an acid salt, crystallized in very fragrant needles, of an acrid taste, which in pharmacy are distinguished by the names of *flowers of benjamin*. Chemists formerly supposed it to be a mineral acid modified; but at present, the particular and characteristic properties which have been distinguished in it do not permit us to doubt but that it is a vegetable acid, different from all other acids.

This acid exists in benjamin, balsam of Peru and of Tolu, storax, liquid amber, and the vanilla, around which it crystallizes: Scheele likewise found it in sugar of milk, and extract of urine. It will be seen, at the article Benzoin, that the simple process formerly employed in obtaining it, consisted in sublimation by a gentle fire. Geoffroy discovered, in 1738, that it might be extracted by water, and that this substance was contained ready formed in the benzoin. I have extracted it, by the same process, from balsam of Peru, storax, and the husks of vanilla; but this method affords only a small quantity, because the resin of benzoin, which does not mix with water, envelopes and defends a great part of the acid salt.

In the year 1776, Scheele published, in the Memoirs of Stockholm, important observations upon the benzoic acid. 96 parts of benzoin afforded, by sublimation, between 9 and 10 parts of this sublimed salt, which is very far from the estimation of Spielman, who affirmed that he obtained $\frac{1}{4}$ of the weight of the benzoin made use of. It appears, that the chemist of Strasburg estimated it when mixed with much empyreumatic oil. Scheele boiled water upon benzoin in powder, mixed with chalk, and filtered the liquor, which afforded no salt by cooling. The sulphuric acid being poured upon this liquor, separated the benzoic acid in powder, and showed that this acid had united to the base of the chalk, and had formed a neutral salt, soluble in water; nevertheless, the quantity of concrete acid, precipitated by this process, was not more considerable than that which is obtained by simple lixiviation. Scheele supposed that he should obtain more by employing a

substance capable of acting upon the resin, and facilitating the separation of the salt: potash did not answer this purpose; the resin united at the surface of the fluid in the form of a dense and tenacious oil, which afforded no hopes of a sufficiently complete separation of the acid. Quick-lime succeeded better, and the following process invented by him is used: 4 ounces of quick-lime are extinguished in 12 ounces of water, and 8 pounds of water are added when the ebullition has ceased; 6 ounces of this lime-water are poured over 1 pound of benzoin in powder, with sufficient agitation to mix these two substances; the whole of the lime-water is added by degrees. This mixture by parts prevents the benzoin from uniting into a mass. The liquor is heated over a gentle fire for half an hour, with continual agitation; it is then taken from the fire, and suffered to settle for several hours; the clear liquor is then decanted, and 8 pounds of water thrown on the residue, which, after being boiled for half an hour, is suffered to subside, and, when clear, is added to the preceding fluid. This washing and ebullition is repeated twice more, and the washing is ended by pouring hot water through the residue upon a filtre: all these waters are afterwards reduced to two pounds by evaporation: a small quantity of resin separates; the evaporated liquor being cooled, muriatic acid is added drop by drop, until no more precipitate falls down, and the liquid exhibits a taste sensibly acid; the salt of benzoin is the precipitate in the form of a powder; it is edulcorated on the filtre. If crystals be desired, it may be dissolved in 5 or 6 times its weight of boiling water, which being filtered through a cloth, and suffered to cool slowly, the salt is deposited in flat and very long prisms.

In this process, the lime absorbs the benzoic acid, and forms with it calcareous benzoat, which is very soluble: the resin separates from this salt, which has but a small affinity with it; the muriatic acid, whose attraction for lime is stronger than that of the benzoic acid, seizes the earth, and separates the vegetable acid. The liquor reduced to two pounds by evaporation, is not sufficient to hold the acid in solution, and almost the whole is deposited. The calcareous benzoat has not the smell of benzoin; but as soon as the benzoic acid is separated by the muriatic acid, it resumes the lively smell which is pec-

culiar to that balsamic substance. By this process Scheele obtained 12 or 14 drams of benzoic acid from one pound of benzoïn; whereas sublimation affords no more than 9 or 10. He informs us, likewise, that the purification of this salt by hot water and by crystallization, causes the loss of a great quantity, and that this purification is not necessary for pharmaceutic uses. In fact, this salt, well crystallized, is very difficult to reduce to powder, and the purification has no other object than to separate about two grains of resin in the pound of benzoïn. Lastly, He remarks that the filtration of this acid dissolved in water cannot be made but through a cloth, as it separates quickly, and in proportion as the liquor cools, the salt closes the pores of the paper, and the filtration cannot proceed.

Since these experiments were made by Scheele, Lichtenstein has published, in Germany, Observations on the Benzoic Acid, in which he assures us that sublimation affords more of this acid than the process with lime-water; but I think, with Scheele and Morveau, that this cannot be understood but of the purified salt.

The pure benzoic acid has a slightly sour, penetrating, hot, and acrid taste; its smell is but slightly aromatic, and it reddens the colour of turnsole very well.

Heat volatilizes it, and at the same time singularly increases its odour. If it be exposed to the action of the blow-pipe in a silver spoon, it liquifies, according to the observation of Lichtenstein, and evaporates without inflaming. If it be suffered to cool, it forms a solid crust, whose surface presents traces of crystallization in divergent rays: it does not burn with flame, unless it be in contact with bodies which are themselves strongly inflamed; the contact of a burning coal only causes it to sublime rapidly.

Air does not appear to have any action upon this acid; for, after having been preserved 20 years in a glass vessel, it was very pure, and had lost nothing of its weight; its smell is dissipated, but it recovers it again by heat.

The benzoic acid is but sparingly soluble in cold water: from the experiments of Wenzel and Lichtenstein, it appears that 400 grains of cold water dissolve no more than one grain, and that the same quantity of boiling water can dissolve 20

grains, of which 19 separate by cooling. Bergman affirms that boiling water can take up $\frac{1}{14}$ of its weight, and that at the mean temperature it dissolves scarcely $\frac{1}{100}$.

The benzoic acid unites to all the earthy and alkaline bases, and forms with them the benzoats of alumine, of barytes, of magnesia, of lime, of potash, of soda, and of ammoniac; the characteristic properties of these several combinations are not known, nor the various attractions of this acid for the bases. Lichtenstein affirms that it prefers the fixed alkalis, and even ammoniac, to the aluminous, magnesian and calcareous earths; but more numerous experiments are required to determine exactly the order of these attractions, more especially as Bergman arranges them differently: according to him, lime separates the alkaline bases, and barytes separates lime: it disengages the carbonic acid from all these bases ^a.

The concentrated sulphuric acid readily dissolves it without heat, and without noise, according to the same chemist; nevertheless it passes to the state of sulphureous acid. The benzoic acid may be separated without alteration by water.

The nitric acid dissolves it in the same manner, and water equally disengages this salt unaltered. Morveau has augmented the action of these two bodies by heat; the nitrous gas was not disengaged but towards the end: and the benzoic acid was sublimed entire and without alteration. However, Hermstadt affirms that by employing the concentrated nitrous acid, the benzoic acid becomes fluid, more fixed, and assumes the characters of the tartareous or oxalic acid; but this result, which is itself very uncertain, requires additional researches. That which appears to be the most certain respecting this acid is, that it differs by its nature and properties from all the other vegetable acids, and that it retains an essential oil, which gives it smell, volatility, combustibility, and solubility in alcohol.

CHAPTER VI.

CONCERNING THE VEGETABLE ACIDS, WHICH ARE PARTLY SATURATED WITH POTASH; AND CONCERNING THE SAME ACIDS IN A STATE OF PURITY.

IN the fourth chapter we have distinguished a peculiar species of vegetable acids, which we have observed are partly combined with potash. We are acquainted with two acids in this situation, namely, the acid of tartar, and that of forrel. We distinguish these partly neutralized acids by the names of *acidules*; the one tartareous, and the other oxalic.

§ 1. *Concerning the Tartareous Acidule, or Tartar, and the Pure Tartareous Acid.*

The tartar of commerce is an essential acid salt, united to a portion of potash and oil. It is deposited on the sides of casks during the insensible fermentation of wine. It is not produced by the spirituous fermentation, as some chemists have supposed; for Rouelle the younger discovered it ready formed in unfermented wine, or must, and in verjuice. Many other chemists have since found it ready formed in several fruits.

It has the form of irregular plates, disposed in strata, often full of brilliant crystals, and of a vinous acid taste. It is distinguished into white tartar and red tartar, the latter differing from the former only in a greater abundance of an extractive colouring matter.

Crude tartar exposed to heat in close vessels, affords a reddish acid phlegm, an oil at first light, and afterwards ponderous, coloured, and empyreumatic; a small quantity of ammoniac, and much carbonic acid, which Hales, Boerhaave, and many other chemists supposed to be air. A coal remains, which contains a large quantity of carbonat of potash, and is easily burned. Vegetable alkali, of considerable purity, is obtained by the combustion and incineration of tartar.

With this intention, pulverized tartar is wrapped up in papers, which are afterwards dipped in water; these are ranged

in a furnace, between two strata of charcoal, which being set on fire, the tartar burns, and is calcined; when the fire is burnt out, the papers of tartar are found in their original form; these are lixiviated with cold distilled water, which, after filtration, is evaporated to a pellicle, and suffered to cool, in order to separate the sulphat of potash, which crystallizes by repose. The fluid solution being decanted off, is evaporated and crystallized a second time; and this process is repeated as long as any crystals of sulphat of potash are afforded: after which it is evaporated to dryness, and affords potash, partly caustic, and partly combined with carbonic acid. This is what is called salt of tartar; by treating it with alcohol, the caustic potash is dissolved, and the carbonat of potash remains undissolved.

Tartar is but sparingly soluble in water: one ounce of that fluid, at the temperature of 55 degrees of Fahrenheit, dissolved no more than four grains. As it contains a large quantity of oleaginous colouring matter, it is purified by solution and crystallization, at Aniane and Calvisson, in the neighbourhood of Montpellier. Dr. Fizes has given a full description of this purification, in a memoir printed among those of the Academy in 1725.

The tartar is boiled in water, and filtered while hot; the solution becomes turbid on cooling, and deposits irregular crystals, which form a paste; the paste is boiled in copper vessels, together with water, mixed with an argillaceous earth, brought from Merviel, two leagues from Montpellier. A scum rises to the top, which is carefully taken off, and is at length succeeded by a saline pellicle. The fire is then put out; and the pellicle being broken, falls to the bottom, among the crystals which precipitated from the solution. The earth, which fouls these crystals, is washed off with cold water, and they are then sold under the name of *cream of tartar*, or *crystals of tartar*; which differ only in the circumstance, that the cream is formed at the surface, while the crystals are deposited at the bottom of the liquor. The white clay appears to deprive the tartar of its superabundant, oily, and extractive matter.

Tartar, according to Desmaretz, is purified in a somewhat different manner at Venice. The pulverized salt, being dis-

solved in boiling water, deposites its impurities, from which it is carefully separated, and the liquor affords crystals by cooling. These crystals are re-dissolved in water, gradually heated; and as soon as it boils, beaten whites of eggs, with sifted wood ashes, are thrown in. This mixture of ashes is made fourteen or fifteen times; the scum is taken off, and the liquor left to cool. A pellicle of very white saline crystals is soon formed, which, after the water is decanted, are suffered to dry. This method changes the nature of the tartareous acidule, by converting a part into tartaric of potash. The chemical properties of the cream of tartar, or the tartar purified in the neighbourhood of Montpellier, must be examined, in order to discover the nature of the pure tartareous acidule.

Very pure tartareous acidule is crystallized, though irregularly; it has an acid taste, less vinous than that of crude tartar. On hot coals, it emits much smoke, of a penetrating empyreumatic smell, and itself becomes black and carbonaceous. If this substance be distilled in an earthen retort, with a receiver, connected with an inverted vessel of water, by means of a tube, and the fire be gradually raised, a phlegm, almost colourless, and scarcely acid, first comes over; next a stronger acid, of a deeper colour; and afterwards an oil, which becomes more and more coloured, consistent, and empyreumatic; and last of all, the concrete ammoniacal carbonat, and a large quantity of carbonic acid. A very abundant coal remains in the retort, which, lixiviated without incineration, affords a large quantity of carbonat of potash. The distilled products may be rectified by a gentle heat. In this rectification, the phlegm passes over nearly colourless, the oil becomes very white and volatile, the ammoniac partly combines with the acid, and is not obtained separate and pure, but by distilling the last portions of phlegm with the addition of potash. The potash contained in the coal is not produced in the operation, as many chemists have thought, who were not sufficiently acquainted with the nature of cream of tartar, but is all contained originally in this substance. The reaction of the fixed alkali on the oil produces the ammoniac; and the quantity of this volatile salt may be increased, by distilling the oil obtained from the tartareous acidule a second time with the coal it leaves in the

retort. It appears that this formation of ammoniac is owing to the azot of the potash, which unites to the disengaged hydrogen of the oil.

Tartareous acidule is not altered by exposure to air.

It dissolves in twenty-eight parts of boiling water, and crystallizes confusedly by cooling, as we have observed. A certain quantity of earth separates from the solution of this salt, which is doubtless that which was used in its purification: the solution reddens tincture of turnsole, and has an acid taste. If it be left exposed to the air, it becomes turbid, and after some time deposits mucilaginous flocks. The acid is decomposed, and the fluid is found to contain nothing but carbonat of potash. Mr. Demachy first observed this decomposition. Messrs. Spielman and Corvinus have likewise busied themselves on this subject; but Berthollet has made experiments which are still more accurate than those which preceded him. He has observed, that two ounces of the tartareous acidule required eighteen months for their entire decomposition; that it afforded six and a half drachms of carbonat of potash, still oily, and mixed with a small quantity of carbon; that this quantity of alkali answered with sufficient exactness to that which was afforded by the acidule by combustion and calcination. The alkaline residue of the distillation, and this spontaneous decomposition, prove, therefore, that the tartareous acidule contains nearly one fourth of its weight of potash.

The action of siliceous earth, alumine, and barytes, on tartareous acidule, is not known. The chemists of the Academy of Dijon have observed, that magnesia forms with this acidule a soluble salt, decomposable by fixed alkali, and affording, by evaporation in the open air, small prismatic crystals in radii. This tartaric acid of magnesia boils up, and becomes converted into a light coal, by exposure to the action of fire. Poulletier obtained from this combination a gelatinous mass, perfectly resembling mucilage. These phenomena depend on the state of the tartareous acid, which is partly saturated in this vegetable acidulous salt.

The action of lime and of chalk on tartareous acidule has been well described by several chemists. When chalk is thrown into a solution of this acidule, an effervescence is produced, oc-

caused by the disengagement of carbonic acid; and a very abundant precipitate, consisting of a combination of the tartareous acid and lime, is formed. The supernatant liquor contains a neutral salt, which existed, ready formed, in the acidule or *cream of tartar*, and consists of the acid of tartar united to potash; it is known, as we shall presently see, by the improper name of *soluble tartar*. We are indebted to Rouelle the younger for this valuable analysis of tartareous acidule by chalk; which proves, 1. That this substance is composed of a superabundant oily acid and a certain quantity of this acid united to potash in the state of a neutral salt. 2. That the combination of the tartareous acid with lime forms a neutral salt of very difficult solubility. Proust has discovered, that calcareous tartaric, distilled in a retort, leaves a residue, which takes fire by exposure to air, like pyrophorus.

Tartareous acidule unites very well with the different alkalis. If it be added to a solution of carbonate of potash, a strong effervescence is immediately produced, by the disengagement of the carbonic acid. The acidule must be added to saturation, and the liquor filtered, after having boiled for half an hour; after which, the evaporation being continued till a pellicle is formed, the solution, by slowly cooling, affords long quadrangular prisms, terminated by two facets, placed slantwise. This salt is known by the names of *vegetable salt*, *soluble tartar*, *tartarized tartar*, and ought to be called tartaric of potash. It has a bitter taste; is converted into a coal by a strong heat; and is decomposed by distillation, affording an acid phlegm, oil, a large quantity of carbonic acid, and a small quantity of ammoniacal carbonate. It slightly attracts the humidity of the air, and is completely dissolved in four parts of water, at the heat of 120 degrees of Fahrenheit. This solution is decomposed during the course of some months, and leaves the fixed alkali combined with the carbonic acid. The mineral acids decompose it, and precipitate tartareous acidule; it is also decomposed by most metallic solutions.

Tartareous acidule, combined with soda, forms *salt of Seignette*, so called from the name of an apothecary of Rochelle, who first composed it. We give it the name of Tartaric of Soda. It is prepared by dissolving twenty ounces of acidule of

tartar in four pounds of water, and gradually adding very pure crystallized carbonat of soda to saturation, which point is known by an effervescence not being excited by the addition of more alkali. In this combination the tartareous acidule is rendered soluble. The fluid being evaporated till it has nearly the consistence of syrup, affords, by cooling, very beautiful regular crystals, often of a considerable magnitude. They are prisms of six, eight, or ten unequal faces, truncated at right angles at their extremities. These prisms are most commonly bisected lengthwise; and the large face, or base, on which they rest, is marked by two diagonal lines, intersecting each other, and dividing the base into four triangles. Tartaric of soda was at first sold as a secret, but was discovered at the same time by Boulduc and Geoffroy in 1731. It has a bitter taste; is decomposed by the fire, like the tartaric of potash; effloresces in the air, because it contains much water of crystallization, and is nearly as soluble as tartaric of potash, and, like that salt, is decomposed by air, mineral acids, and metallic solutions. The mother water of this salt contains the portion of tartaric of potash, which composes part of the tartareous acidule.

Ammoniac forms with acidule of tartar an ammoniacal tartaric, which crystallizes very well by evaporation and cooling. Bucquet affirms that its crystals are rhomboidal pyramids. Macquer observed some in thick prisms of four, five, or six sides; others thickest in the middle, and terminated by very acute points. The academicians of Dijon obtained them in oblique angled parallelopipedons. Ammoniacal tartaric has a cool taste, and is decomposed by heat: in the air it effloresces: hot water dissolves it more readily than cold; and it crystallizes by cooling. Lime and fixed alkalis disengage the ammoniac; the contact of air, mineral acids, and metallic solutions, decompose it. When it is prepared, it seems that the portion of tartaric of potash, whose union with the tartareous acid constitutes the acidule, or *cream of tartar*, remains in the mother water.

Pott and Margraaf treated cream of tartareous acidule with the mineral acids, and the latter obtained neutral salts, similar to those afforded by each of these acids with potash; whence he concluded, that this alkali exists, ready formed, in this aci-

dule. Rouelle the younger made a number of accurate experiments, which afforded the same results. A pound of tartareous acidule, in very fine powder, was added to a pound of concentrated sulphuric acid; the mixture became hot, and the mutual action of the two substances on each other was assisted by the heat of a water-bath, and by frequent stirring with a glass instrument. This heat being continued ten or twelve hours, the mixture became of the thickness of cream, at which time two or three ounces of boiling distilled water were added, which rendered the whole fluid. Two hours after, the mixture was taken from the fire, and three pints of boiling distilled water were added. This solution was coloured, and opaque, and contained disengaged sulphuric acid, a portion of tartareous acidule not decomposed, and sulphat of potash. The excess of sulphuric acid was then saturated with chalk; and sulphat of lime, with a small quantity of tartareous acidule, was precipitated. The mixture was then filtered and evaporated, till it became reduced to eighteen or twenty ounces; during which, a small quantity of tartareous acidule and of sulphat of lime, fell down. The fluid was decanted off, evaporated a second time, and, by standing, afforded crystals of sulphat of potash; more of which was obtained in the like manner by successive operations. This salt is always mixed with a small quantity of tartareous acidule, and burns on a hot iron. But if a due quantity of distilled water be added, it will be taken up, and the tartareous acidule will remain undissolved. The foregoing process is described by Berniard, who repeated it with success after Rouelle.

The nitric and muriatic acids, treated in the same manner with tartareous acidule, afford nitrat and muriat of potash; which incontrovertibly proves the existence of potash in this substance.

Tartareous acidule acquires solubility, by uniting with borax and boracic acid. According to the experiments of De Laffone, one part of the latter salt may render about four parts of tartareous acidule soluble. This mixed solution affords a greenish, very acid, gummy salt, by evaporation. Common borax, when added to tartareous acidule, converts a part of the acid into tartarit of soda, by reason of the soda which it contains.

Tartareous acidule appears capable of uniting, without decomposition, with most metallic substances, as Monnet and the chemists of the academy of Dijon have shown. But as these combinations have been little examined, we shall only speak, in this place, of those of antimony, mercury, lead, and iron; because they are better known, and are most of them used in medicine.

The combinations of tartareous acidule and antimony, is called *sibiated*, or *antimoniated tartar*: it is the tartarit of antimony and of potash. As it is one of the most important remedies afforded by chemistry, it is necessary to examine its properties with the greatest care. Since the time of Adrian de Mynsicht, who first described this composition, in the year 1631, the process for making it has been greatly varied. The Pharmacopœia, and the writings of chemists, all differ in the antimonial substances directed to be employed, as well as in the tartareous acidule and water, either with respect to quantity, or the method of applying them to each other. Bergman, in his dissertation on this medicine *, has given an excellent section on the different processes heretofore used in preparing tartarit of antimony. The sublimated white, the brown vitreous, or orange oxyds, have been successively prescribed: some direct these substances to be boiled with tartareous acidule, and a greater or less quantity of water, for ten or twelve hours; others direct the ebullition to be continued no longer than half an hour; others again require the filtered lixivium to be evaporated to dryness; and lastly, there are others who direct it to be crystallized, and the crystals only to be used in medicine. Hence it happens, that tartarit of antimony is never the same substance, but possesses various degrees of force, so that its effects cannot be clearly ascertained. And accordingly Geoffroy, who examined many specimens of *antimoniated tartar*, of different degrees of force, found, by the analysis, that the weakest contained from thirty grains to one drachm and eighteen grains of oxyd of antimony. Those of a middle degree of emetic power, a drachm and a half; and the strong-

est, two drachms and ten grains. Vitreous oxyd of antimony has been chosen in preference to other antimonial substances, because it is one of the most soluble by the acidule of tartar; but this metallic glass may be more or less oxydated, and the different degrees of oxydation must affect its emetic power. However, if very transparent vitreous oxyd of antimony, previously well levigated, be boiled in water, with an equal weight of tartareous acidule, till the latter is saturated, and this solution be filtered and evaporated by a gentle heat, crystals of antimonial tartaric are obtained, by standing, whose emetic power appears to be sufficiently constant. The liquor being decanted and evaporated, affords new crystals for several successive times. The mother water contains sulphur, tartaric of potash, and a certain quantity of antimoniated alkaline sulphure. When the mixture of tartareous acidule, vitreous oxyd of antimony, and water, has been boiled for the preparation of antimoniated tartaric, and passed through the filtre, a yellow or brown gelatinous substance remains behind, which Rouelle has examined. According to Proust, this jelly affords, by distillation, a very inflammable pyrophorus.

Macquer proposes to substitute the white oxyd, precipitated from muriatic of antimony by water, in the place of vitreous oxyd of antimony, in the preparation of emetic tartar. This oxyd is itself a violent emetic, which Macquer considered as always the same. Bergman has adopted the opinion of Macquer; and since that time, a tartaric of antimony has been prepared in the laboratory of the Academy of Dijon according to the method of Bergman and De Laffone. This medicine has been used with the greatest success: it operates, in a dose of three grains, without fatiguing the stomach and intestines.

Tartaric of antimony crystallizes in very transparent trihedral pyramids, decomposable by heat, which converts them to a coaly substance. It effloresces in the air, and becomes a white farinaceous powder; it is soluble in sixty parts of cold water, or in a much less quantity of hot water. It crystallizes by cooling; and is decomposed by lime and alkalis. Calcareous earth, and pure water, in a large dose, are capable of decomposing it; whence it follows, that it ought to be administered only in distilled water. Alkaline sulphures, and sul-

phurated hydrogen gas, precipitate from it a red powder, or kind of sulphurated oxyd of antimony, which may serve as a test for the presence of this salt in all liquors containing it. Iron seizes the acid of tartar, and separates the oxyd of antimony; antimoniated tartar ought not, therefore, to be prepared in vessels of this metal. Durande, physician and professor at Dijon, proposes that this medicine be made publicly, and by one uniform process, established by law, as the theriaca is made; and we are convinced, that the greatest advantages would arise to the practice of physic from such a regulation being adopted.

It appears, that the tartaric acid contains the portion of tartaric acid of potash, which forms part of the tartareous acidule, and that it is a kind of triple salt.

The tartareous acid may be combined with mercury by two methods. The one mentioned by Monnet, consists in dissolving six parts of tartareous acidule in boiling water, with one part of mercury, precipitated from the nitric acid by the carbonate of potash. This liquor, filtered and evaporated, affords crystals, that are decomposable by pure water. The second method of uniting mercury with the tartareous acidule, consists in pouring a nitric solution of this metal into a solution of tartaric acid of potash, or of soda: a precipitate of mercurial tartaric acid is afforded, and the nitrate of potash, or soda, remains dissolved in the liquor.

Tartareous acidule has a sensible action on the oxyds of lead. Rouelle the younger has ascertained, that the tartaric acid of lead, produced in this operation, does not remain dissolved, but that the liquor, by evaporation, affords pure tartaric acid of potash, which was readily formed in the tartareous acidule. This is one of the processes he has made use of to prove, that potash exists in tartar.

Copper, and its oxyds, are readily attacked by the tartareous acidule: the result is a salt, of a beautiful green, capable of crystallization, but hitherto little examined.

Iron is very strongly acted on by tartareous acidule. A medicine, called *chalybeated tartar*, is prepared, by boiling four ounces of levigated iron filings with one pound of white tartar, in twelve pounds of water. When the tartar is dissolved, the

liquor is filtered, and deposits crystals, more of which may be obtained by subsequent evaporation. To prepare the *tartarized tincture of Mars*, a paste is made, with six ounces of iron filings, one pound of white tartar in powder, and a sufficient quantity of water. This mixture is left at rest for twenty-four hours; after which twelve pounds of water are added, and the whole boiled for two hours; fresh water being added in proportion as the evaporation goes forward. The liquor is then decanted, filtered, and thickened, by boiling to the consistence of syrup; after which one ounce of spirit of wine is added. Rouelle ascertained, that potash exists at liberty in this tincture, and that by treating it with acids, neutral salts, with base of this alkali, are obtained. There are likewise two other medical preparations, formed by the combination of the tartareous acid and iron. The one is *soluble martial tartar*, consisting of one pound of the *tartarized tincture of Mars*, and four ounces of tartaric acid of potash, evaporated to dryness. The other is known by the name of *martial balls*. They are made by mixing, in a glass vessel, one part of steel filings, and two parts of white tartar in powder, with a certain quantity of brandy; when the brandy is evaporated, the mass is pulverized, and more brandy added, which is suffered to evaporate as before. This process is repeated till the mass becomes tenaceous, when it is formed into balls.

Crude tartar is very useful in the art of dying, and it is likewise made use of by hatmakers.

The different preparations of tartareous acidule which we have enumerated, are mostly used in medicine; pure cream of tartar is considered as a cooling antiseptic. In the dose of half an ounce, it purges gently, and without exciting nausea. The tartaric acid of potash and of soda are often used, in conjunction with other purgative medicines, in the dose of a few drachms. Tartaric acid of antimony is one of the most useful and efficacious medicines afforded by chemistry. This salt is emetic, purgative, diuretic, diaphoretic, or deobstruent, according to the doses and processes used in administering it. It often produces all these effects at one time. It may also be considered as a powerful alterative, of excellent use in removing obstructions of the viscera, when given in small doses often repeated. It is

administered as an emetic, in the dose of from one to four grains, dissolved in water. It is mixed, in the dose of a grain, with other purgatives, whose action it assists. And lastly, when given in the quantity of half a grain, greatly diluted with water, it acts as an alterative. De Laffone has discovered, that tartaric acid of antimony is rendered very soluble in water by the mixture of ammoniacal muriat; and that a mixed salt, similar to ammoniaco-mercurial muriat, is produced. Berthollet has discovered, that the decoction of Peruvian bark destroys the emetic effect of tartaric acid of antimony. *Chalybeated tartar, soluble martial tartar, and the tartarized tincture of Mars,* are used as tonic and aperient medicines.

Such are the properties of the native tartareous acidule, or of the tartareous acid combined by nature with a certain quantity of potash: it was necessary to examine it with care, because this substance was very useful, and much employed in this state. But this is not the pure tartareous acid, whose properties and characters are of equal importance to be known. Mr. Retzius has published, in the Memoirs of Stockholm for 1770, a process, invented by Scheele, for the extraction and purification of this acid. Washed chalk is thrown into a solution of 2 pounds of cream of tartar in boiling water, until there is no longer any effervescence nor acid at liberty; somewhat more than 1-4th of the weight of the cream of tartar is required: the precipitate of calcareous salt which is formed must be then collected on the filtre, and washed with warm water; it commonly amounts to 32 or 33 ounces, on account of the water it retains. The liquor decanted from this precipitate affords, by evaporation, nearly the half of the weight of the tartaric acid of potash, which has not been decomposed: 9½ ounces of dense sulphuric acid, diluted with 5 pounds 5 ounces of water, is poured on the calcareous salt of tartar, and the mixture is left to digest for 12 hours, being agitated from time to time. The liquor is then decanted from the sulphat of lime; and the water is evaporated, after having ascertained that it does not contain sulphuric acid. For this purpose, a few drops of the acetit of lead, or sugar of lead, are added; if the precipitate which is formed be entirely soluble in vinegar, the lixivium does not contain sulphuric acid;

if it is not soluble in this fermented acid, it contains the sulphuric acid, of which it may be cleared by digesting the liquor on a certain quantity of calcareous tartaric. Lime may be used instead of chalk, to obtain the tartareous acid; but as this alkaline earth decomposes the tartaric of potash contained in the tartareous acidule, the lixivium contains only alkali instead of the tartaric of potash, as in the former process. The use of quicklime in this decomposition affords a great quantity of acid, because this earth decomposes twice its weight of tartareous acidule or cream of tartar.

The pure tartareous acid obtained in the liquid state by either of the above described processes, must be evaporated to dryness; afterwards redissolved and crystallized, either by gentle evaporation, according to Mr. Pœcken, or by cooling the liquor evaporated to the consistence of a syrup, according to Bergman. It is obtained in the form of small needles acutely pointed, or fine prisms, whose form is difficult to be determined. Bergman describes them as small diverging leaves; Mr. Retzius compares them to hairs entwined together. They are at first very white, but those which are obtained toward the end are yellow.

The crystallized tartareous acid melts, fumes, blackens, and even takes fire by the contact of ignited bodies. By distillation it affords, like the tartareous acidule itself, an acid phlegm, a small quantity of oil, and much gaseous carbonic acid, mixed with carbonated hydrogen gas. The charcoal which remains, contains neither acid nor alkali; which proves that this last is not formed by the decomposition of the tartareous acid by fire. This acid, though purified, is always oily. It is for this reason that we distinguish it, in the new nomenclature, by the name of tartareous acid, and its salts by that of tartaric.

It is unalterable in the air, is much more soluble than tartareous acidule; its taste is very penetrating; it reddens the tincture of violets, and likewise that of turnsole; it perfectly dissolves alumine, and forms with it an aluminous tartaric, which assumes a gummy or mucilaginous appearance by evaporation.

In combination with magnesia, the pure tartareous acid like-

wife forms a kind of gelatinous matter instead of crystallizing.

With lime it forms a salt which is scarcely soluble.

If a small quantity of potash be poured into its solution, crystals of the tartareous acidule, or *cream of tartar*, fall down. This discovery of Scheele and Bergman throws the greatest light on the nature of this vegetable salt: there no longer remain, as Morveau observed, any inquiries to be made concerning the composition of tartareous acidule, it is known to be the tartaric of potash with excess of acid. But what is most singular is, that this acid, which is very soluble, immediately loses this property when it is about half saturated by the alkali, which is, nevertheless, itself very soluble. This fine experiment likewise proves that the tartareous acid is not at all altered by the process of Scheele, since it forms, with about $\frac{1}{4}$ or $\frac{1}{3}$ of its weight of potash, an acidulous salt, which is perfectly similar to that formed by nature. If the proportion of potash be increased, a neutral salt is formed, which is perfectly saturated and soluble: it is the tartaric of potash or *vegetable salt*.

The tartareous acid united to soda constitutes a neutral crystallizable salt, or tartaric of soda very pure. With ammoniac it likewise affords an ammoniacal tartaric, which is crystallizable. Mr. Retzius affirms, that if the tartareous acid be combined with a quantity of ammoniac, much less than is necessary to saturate it, an ammoniacal tartareous acidule is formed, which is of sparing solubility, and crystallizes like the tartareous acidule of potash, or common cream of tartar.

Though the tartareous acid has less affinity with alkalis than the mineral acids, yet these, by decomposing the tartaric of potash and of soda, do not completely separate their bases, but disengage the tartareous acid in the state of acidule of potash or of soda. The disengaged tartareous acid itself decomposes in part the sulphat, nitrat, and muriat of potash, and separates the portion of alkali which is required to convert it into the state of tartareous acidule, or acidulous tartaric of potash. It does not produce the same effect upon the nitrat and muriat of soda.

Hermstadt affirms, that the tartareous acid becomes the oxalic acid by means of the nitrous acid. Bergman could not

produce this change: but his want of success was probably owing to his not having employed a sufficient quantity of nitric acid. As nitrous gas is afforded during this conversion, it appears that the oxalic acid differs from the tartareous acid only in containing a greater quantity of oxygen.

The tartareous acid has no action upon platina, gold, and silver; it dissolves their oxyds or calces; it acts only insensibly upon copper, lead, and tin; it dissolves their oxyds, and deprives that of lead of its red colour.

It dissolves iron with a very slow effervescence.

It produces no alteration whatever in antimony in the metallic state, but it dissolves the vitreous oxyds of that semi-metal very well.

It takes lime from the nitric, muriatic, acetous, formic, and phosphoric acids.

It precipitates the nitric solutions of mercury, the muriatic solutions of lead, &c.

Its attractions, pointed out by Bergman, are in the following order: Lime, barytes, magnesia, potash, soda, ammoniac, alumine, the oxyds of zink, iron, manganese, cobalt, nickel, lead, tin, copper, bismuth, antimony, arsenic, silver, mercury, gold, platina, water, and alcohol.

§ 2. *Concerning the Oxalic Acidule, or Salt of Sorrel of Commerce, and concerning the pure Oxalic Acid.*

Salt of sorrel of commerce, or the oxalic acidule, is obtained in great quantities in Switzerland, in the Hartz, in Thuringia, and Swabia, from the juice of the sorrel, called, by Linnæus, *oxalis acetosella*. One hundred pounds of this plant afford, according to Savary, fifty pounds of juice by expression; and this affords only five ounces of concrete salt, by evaporation and crystallization. In commerce, the salt of sorrel of Switzerland, which is the finest and whitest, is distinguished from that of the forests of Thuringia, which is foul and yellowish.

It has long been known that the juice of sorrel affords an acid salt by evaporation. Duclos mentions it in the Memoirs of the Academy for 1668. Junker likewise speaks of it. Boerhaave has described, with much care, the process proper for obtaining this salt, which he compares to tartar. Margraaff

discovered the presence of potash in the oxalic acidule, as well as in that of tartar. But the accurate knowledge of the nature of this salt has been acquired in consequence of the labours of Messrs. Savary, Wenzel, Wiegleb, Scheele, and Bergman.

The oxalic acidule has the form of small white, opaque, needle-formed, or lamellar crystals. Their exact form has not yet been determined, though Capeller and Ledermuller have represented it as seen in the microscope. Romé de Lisle defines them as very long parallelopipedons. These are assemblages or groups of thin and long plates joined at one end and separated at the other.

Its taste is eager, penetrating, and at the same time rough or austere. It strongly reddens the tincture of turnsole and blue paper; 480 grains of this acidule distilled in a retort by a well regulated fire, by Wiegleb, afforded 150 grains of a very acid phlegm, without smell or colour. There remained 160 grains of a grey salt, from which 156 grains of vegetable alkali were obtained. About four grains of concrete acid salt likewise sublimed to the neck of the retort, but there did not pass one single drop of oil.

The loss in this distillation was 166 grains; but as Wiegleb does not mention the elastic fluids which must have been disengaged in this analysis, it is probable that the loss is owing to the water in vapours, and carbonic acid gas, mixed with a small quantity of hydrogen gas and carbon. From this analysis, compared with that of the tartareous acid, we see that the oxalic acidule is not so oily as this last; and accordingly it is found, that the liquid acid obtained in this distillation, is the pure oxalic acid; whereas the tartareous acidule, treated by the fire, affords an acid which is altered and is different from the tartareous acid itself. We distinguish it by the name of the pyro-tartareous acid. It is on account of this smaller quantity of oil, contained in the acid of sorrel, that we have distinguished it by the names of oxalic acidule and acid; whereas the more oily acid of tartar has been named, according to the rules of the methodical nomenclature, tartareous acid.

The oxalic acidule, exposed to the air, suffers no change when it is pure: it is more soluble than the tartareous acidule.

According to Wiegleb, one drachm of the oxalic acidule of Switzerland requires no more than six drachms of boiling water, but it is precipitated entirely by cooling, notwithstanding the addition of six drachms of cold water. According to Wenzel it is much more soluble; for, by his experiments, 960 parts of boiling water take up 675 of this salt; but its solubility appears to vary according to its greater or less state of acidity, which no doubt depends on the plant from which it is extracted.

The oxalic acidule unites to barytes, magnesia, soda, ammoniac, and forms with them triple salts. Lime decomposes it, by seizing its whole acid, as well that which is at liberty, as that which is combined with potash: 100 grains of chalk decompose 137 grains of the oxalic acidule. The precipitate of calcareous oxalat which is deposited weighs 175 grains; the supernatant liquor affords 32 grains of carbonat of potash by evaporation. This process cannot be used to prepare the pure oxalic acid in the same manner as the tartareous acid is obtained in a state of purity, because the calcareous oxalat cannot be decomposed by the sulphuric acid, as the calcareous tartaric is: on the contrary, the attraction of the oxalic acid for lime is so strong, that it takes it from all other acids; and a sure means of ascertaining the purity of the oxalic acidule, or salt of sorrel of commerce, consists in pouring its solution into water, charged with a solution of calcareous sulphat. If this acidule be truly extracted from sorrel, an abundant precipitate is afforded.

The sulphuric acid facilitates the disengagement of the oxalic acid from this acidule by means of heat, according to Wiegleb. The nitric acid decomposes the acidule, and separates the alkali with much greater difficulty from this than from the tartareous acidule, according to the researches of Margraaff.

The oxalic acidule attacks iron, zinc, tin, antimony, and lead; it dissolves the oxyds of all the other metals, and forms with them triple salts, which are crystallizable and not deliquescent, in which the potash remains constantly united to the acid: it precipitates the nitric solutions of mercury and of silver. Bayen, by evaporating the liquor which flows above these precipitates, obtained nitrat of potash, and confirmed the presence of alkali in this acidule.

To prepare the oxalic acid, and deprive it of the portion of potash which renders it acidulous, we may, as has already been shown, avail ourselves of distillation; but this process affords only a small quantity; and that of Scheele, which is much more certain and easy, is preferable. The oxalic acidule, or salt of sorrel, is saturated with ammoniac. Into the solution of this triple oxalat, composed of the acid with ammoniac and potash, the nitrat of barytes is poured. A precipitate is formed of oxalat of barytes, and the nitric acid retains the alkalis. The barytic oxalat, when well washed, is decomposed by the addition of sulphuric acid, which combines with the barytes, and remains insoluble at the bottom. The fluid being decanted, is to be assayed by the addition of a small quantity of barytic oxalat, dissolved in boiling water, to separate the portion of sulphuric acid which may be contained in it; and when no more precipitate is afforded, the liquid, which contains the pure oxalic acid, may be decanted. This being duly evaporated, affords, by cooling, the crystallized salt in quadrilateral prisms, whose faces are alternately broad and narrow, and are terminated by dihedral summits. These crystals often have the form of square or rhomboidal plates.

This concrete acid has a very penetrating sour taste; seven grains give to two pounds of water a sensible degree of acidity; it reddens all blue colours: one grain of the salt gives to 3600 grains of water, the property of reddening paper tinged with turnsole.

The concrete oxalic acid, exposed to a mild heat, becomes dry, and covered with a white crust; soon afterwards it is reduced to powder, with the loss of three tenths of its weight. By distillation in a retort with a stronger heat, though still moderate, it liquefies, becomes brown, boils up, affords an acidulous phlegm, sublimes in part without alteration, at the same time that a mixed gas, consisting of carbonic acid and hydrogen gas, is disengaged.

If a very strong heat be applied, more gas, less of concrete sublimed acid, and more acidulous phlegm which is not crystallizable, are afforded: there remains at the bottom of the retort a grey or brown mass, forming $\frac{1}{10}$ of the acid employed. If laid upon ignited charcoal in the air, it exhales in a

very acrid white fume, which strongly irritates the lungs, and leaves only a white residue without any coaly matter. Such is the result of the decomposition of the oxalic acid by heat, as observed by Bergman. The Abbé Fontana obtained nearly double the product of gas; but this depends, as we have already shown, upon the stronger heat he gave, with the intention of completely decomposing this acid.

The concrete oxalic acid, exposed to a moist air, remains deliquescent, but it rather becomes dry in a dry atmosphere: cold water dissolves half its weight. When the crystals of this acid are thrown into cold water, they produce a slight noise, which indicates a sudden breaking of the particles. The specific gravity of this cold solution is 1,0593, according to Morveau. If the water of solution be evaporated, no acid vapour arises, even by ebullition. Boiling water dissolves its own weight of this concrete acid salt. One half is precipitated in crystals by cooling.

The oxalic acid dissolves alumine. The evaporated solution affords a yellowish, transparent, sweet, astringent matter, which becomes moist in the air, and reddens turnsole. This salt boils up in the fire, loses its acid, and leaves the alumine of a brown colour. It is decomposable by mineral acids.

This acid, combined with barytes, forms a salt scarcely soluble, which affords angular crystals, when the acid is in excess. Hot water, by carrying off this excess, renders them opaque, pulverulent, and insoluble.

When combined with magnesia, it affords a white salt in powder, decomposable by the fluoric acid, and by barytes.

Saturated with lime, the oxalic acid affords a pulverulent salt insoluble in water, and not decomposable but by fire; because the affinity of this acid with lime is such, that it takes it from every other. Bergman, consequently, proposes the oxalic acid as a test to discover the presence and quantity of lime contained in mineral waters, whether disengaged, or in combination with any acid. Calcareous oxalat turns syrup of violets to a green.

The oxalic acid unites with the potash, and may be crystallized, provided either of the principles be in excess. This salt, which is very soluble in water, is decomposable by the action

of fire, and by the mineral acids. If the pure oxalic acid be added, drop by drop, a precipitate is soon formed, which is known to be the oxalic acidule or *salt of sorrel*, analogous to that of commerce.

Combined with two parts of soda, the oxalic forms a salt of difficult solubility, which dissolves more readily in hot than cold water, and turns syrup of violets to a green. An excess of acid forms an acidulous oxalat of soda, of sparing solubility.

With ammoniac it affords an ammoniacal oxalat, which by slow evaporation, crystallizes in quadrilateral prisms decomposable by fire, and convertible into an ammoniacal carbonat, formed by the destruction of the oxalic acid. An excess of this acid, poured into the solution of this salt, precipitates an oxalic ammoniacal acidule, which falls down in crystals much less soluble than the pure neutral salt.

The oxalic acid is soluble in the mineral acids. It gives a brown colour to concentrated sulphuric acid, and is decomposed by nitric acid, which reduces it to carbonic acid.

In general, it combines more readily with metallic oxyds than with metals.

1. With oxyd of arsenic it forms very fusible, volatile, prismatic crystals, decomposable by heat.

2. With cobalt, a pulverulent salt of a light rose colour, and difficultly soluble in water.

3. With oxyd of bismuth, a white salt in powder, of difficult solubility.

4. With oxyd of antimony, a salt in crystalline grains.

5. With oxyd of nickel, a white or greenish yellow salt, of difficult solubility.

6. With oxyd of manganese, a salt in a white powder, which becomes black by heat.

7. With zink, which it dissolves with effervescence, it forms a white pulverulent salt.

8. With oxyd of mercury, a white pulverulent salt, which becomes black by the contact of light. This acid decomposes the sulphat and nitrat of mercury.

9. It at first blackens tin, which afterwards becomes covered with a white powder. The salt it forms with this metal is

of an acrid taste, and by a well conducted evaporation, crystallizes in a prismatic form. If quickly evaporated, it affords a transparent mass resembling horn.

10. It tarnishes lead, but dissolves the oxyds much more readily than the metal itself. The saturated liquor deposits small crystals, which may likewise be obtained by pouring oxalic acid into a solution of the nitrat, or muriat of lead, as well as into the acetit of that metal.

11. It attacks iron filings, and hydrogen gas is disengaged from this solution by the decomposition of the water. Oxalat of iron is styptic, and affords prismatic crystals, of a greenish yellow, decomposable by heat. The yellow oxyd of iron, united to this acid, presents a yellow salt, similar to that which is obtained by pouring a solution of oxalic acid into a solution of sulphat of iron.

12. It acts on copper, and completely dissolves the oxyds of that metal, forming a salt of a light blue colour, and of difficult solubility. This salt may likewise be obtained by precipitating the solutions of copper in the sulphuric, nitric, muriatic, and acetous acids, by the addition of the oxalic acid.

13. The oxyd of silver, precipitated by potash, is sparingly dissolved in this acid. The best manner of procuring this salt, is to precipitate the nitric solution of this metal by oxalic acid: a white precipitate is formed, scarcely soluble in water, which becomes brown by the contact of light.

14. This acid has scarcely any action on the oxyd of gold.

15. Lastly, It dissolves the precipitate of platina, made by soda. This solution is yellowish, and affords crystals of the same colour. Such are the phenomena described by Bergman, respecting the combinations of oxalic acid with metallic substances.

This celebrated chemist made all these combinations by employing the artificial oxalic acid, prepared by the nitric acid and sugar.

Sugar, as well as all mucilages, extracts, mild oils, and flour, afford, when treated by the nitric acid, an acid perfectly similar to the pure oxalic acid, as Scheele has ascertained. All these matters, and even a great number of animal substances, as Berthollet has discovered, contain, therefore, the

oxalic radical, to which oxygen only is wanted to convert it into oxalic acid.

Bergman is the first who discovered that sugar, treated by the nitric acid, formed an acid different from all others, and which was called the acid of sugar or saccharine acid, for several years, until Scheele had shown that this acid is absolutely of the same nature as the oxalic acid, obtained from the salt of sorrel by the process before described. He has ascertained this identity in the most convincing manner, by forming again the oxalic acidule of sparing solubility, or the salt of sorrel, by combining a small quantity of soda with the saccharine acid. Here, therefore, we have a vegetable acid which does not exist as an acid except in a few vegetable substances, but whose base is extremely abundant in these matters, and which appears to pass without alteration into the bodies of animals. We shall show, in the following chapters, that this acid, like all the other vegetable acids, is probably a compound of hydrogen, carbon, and oxygen, and that it does not differ from them but in the particular proportions.

The oxalic base or radical appears to exist more abundantly in insipid matters than in sugar; though it was at first supposed that saccharine bodies afforded it in the greatest abundance. Bergman obtained from sugar no more than one third of its weight of oxalic acid, and Berthollet obtained from wool more than half the weight he made use of.

The pure oxalic acid is of no use, excepting in chemical laboratories, where it is more especially employed to determine the presence of lime. The oxalic acidule, or salt of sorrel, is employed to take out ink spots from white stuffs, wood, ivory, &c. which it does by virtue of its attraction for iron; but the pure oxalic acid might be advantageously substituted instead thereof, on account of its greater solubility.

NOTES ON CHAPTERS V. & VI.

CITRIC ACID.

^a **RICHTER** has given a different process for obtaining this acid in a very pure and concentrated state. Lemon juice is to be saturated with potash; and to this solution, when filtered, a solution of acetit of lead is to be added, so long as any white precipitate continues to be formed. In this process, the citric acid unites with the lead, and the acetous with the alkali. The citrat of lead, after beingedulcorated with water, in order to dissolve and to carry off any of the acetit which may adhere to it, is to be digested with a sufficient quantity of diluted sulphuric acid, and stirred frequently. During this digestion, sulphat of lead is formed, and the disengaged citric acid exists in the supernatant liquor. Very beautiful crystals of citric acid will be obtained, by evaporating this liquor with a gentle heat.

As the citric acid takes lead directly from the acetous acid, the citrat of lead may be obtained by adding lemon juice to the acetit of lead. But the mucilaginous parts of the juice are not in this case so completely separated as when this juice is first saturated with alkali. *Richter ueber die neuern. Gegen. St. I. f. 59.*

Lemon juice contains also, according to Hermbstadt, a quantity of the malic acid, which forms a soluble salt with lime, when this substance is employed to obtain the citric acid. In following, therefore, the process recommended by Richter, the malat will be formed along with the citrat of lead. Adet found the citric and malic acids in his analysis of the juice of the pine-apple. *Ann. de Chem. Tom. XXV. p. 32.*

^b Dize, who prepared the concentrated citric acid on a large scale, found, that its crystals consisted of rhomboidal prisms, with inclined planes of 120° and 60° , and terminated by a summit which has 4 trapezoidal surfaces. An ounce of distilled water dissolves an ounce and 2-8ths of citric acid. Cold is produced during the solution. Water, at the boiling point, dissolves double of its weight of this acid. 100 parts of citric acid, dissolved in a sufficient quantity of boiling water, dissolves 50 parts of calcareous citrat. *Journ. de Phys. 1794. Tom. II. p. 231.*

^c The combination of citric acid with potash is not easily susceptible of crystallization. Citrat of potash attracts readily moisture from the atmosphere.

Citric acid forms with soda a salt in the shape of long and small needles. This salt also crystallizes with difficulty. The crystals, which contain much water of crystallization, become opaque, and deliquesce in the air.

With ammoniac, this acid forms a salt which has only a very slight tendency to crystallization, and which attracts humidity strongly from the air. The citrat of ammoniac is decomposed by heat; the ammoniac flies off in the gaseous state, while the acid is resolved into its component parts. Richter remarks, that the taste of the alkaline citrats, particularly of the last, is agreeably cooling.

Saturated with lime, citric acid forms a white powder very difficult of solution in water, but which becomes readily soluble by an excess of acid.

The solution of magnesia in citric acid does not afford regular crystals, but a white precipitate, which, according to Scheele, dissolves readily in water.

Citrat of barytes is obtained in a pulverulent form. It is rather more easily soluble in water than the citrat of lime.

Alumine forms^a with citric acid a saline precipitate, which by dryness becomes not unlike a mass of gum-arabic.

Citric acid expels the carbonic and boracic acids from their combinations with alkalis. It is distinguished from the tartaric acid, in not being able to decompose the muriat of potash; and from the oxalic, from its not decomposing the sulphat of lime.

The nitrat and acetit of mercury are decomposed by the citric acid. It gives a green colour to the acetit and sulphat of iron. *Richter ueber die neuern. Gegen.* St. VI. f. 68.

^a Richter agrees with Scheele in saying, that the citric is not convertible into the oxalic acid by treating it with the nitric acid; but Weftrumb and Hermbstadt are of a different opinion. Weftrumb, indeed, allows, that when he used the nitric acid in too large a proportion, little or no oxalic acid was formed. *Kleine abhandlungen*, B. II. f. 252.

GALLIC ACID.

^a MR. PÆPENBRING published a short memoir in Crell's Journal for the year 1786, in which he endeavoured to prove, that there exists an acid in nut-galls independently of the astringent principle; and that it is to this acid, and not to the astringent principle, they owe the property of giving a black colour to the solutions of iron. This opinion, which was supported by its author by only very inaccurate and equivocal experiments, has been fully established by a very interesting discovery of Seguin's. This chemist has discovered, in the infusions and decoctions of astringent barks, a new principle, to which, from the effects it produces on animal matters, he has given the *Tannin*. Seguin has not been able to exhibit this substance by itself, for it is always mixed or combined in vegetables with the gallic acid.

If water be poured at different times on oak-bark, the water of the first infusion will contain the tannin and gallic acid mixed or combined together. The presence of the tannin is known by adding to the solution a little animal jelly or glue, with which it immediately forms a copious yellowish precipitate, insoluble in water, imputrescible, and which becomes hard and brittle by drying.

If the waters which have been successively employed to separate the soluble part from oak-bark be kept apart, it will be found, that the first infusions form a copious precipitate with the solution of glue, while they at the same time give a red colour to the tincture of turnsole, decompose metallic solutions, and form a black precipitate with iron. The waters, again, which have been last employed have a less austere taste, and form no precipitate with animal jelly; but they exhibit with reagents all the known properties of gallic acid. There exists, therefore, two substances in these infusions which possess different properties.

The tannin appears to be more soluble in water than the gallic acid, for it is sooner extracted from the bark by infusion.

The liquor from which the tannin has been all separated by animal jelly, still contains a portion of gallic acid, which precipitates the sulphat of iron.

Tannin affords a very convenient test for ascertaining the quantity of gelatine contained in any fluid.

The gallic acid, according to Seguin, is sometimes found alone in vegetables, or at least united to only a very small portion of tannin, as in the cinchona, coffee, scrophularia, millefolium, chamomile and arnica. The infusions of these plants precipitate the sulphat of iron, but produce no effect on the glue of animals. Tannin has been discovered in a great variety of vegetables. *Journ. de Polytech.* Tom. IV. p. 678.

Proust has lately discovered a method of separating tannin from the gallic acid by means of muriat of tin. For this purpose, a solution of muriat of tin is to be poured into a decoction of nut-galls. A copious yellowish precipitate is immediately produced. After diluting the liquor with water, and filtering it, in order to separate any remaining portions of the precipitate, the liquor is found to contain gallic acid, muriatic acid, and the muriat of tin. The precipitate is a combination of the tannin principle with the oxyd of tin.

To obtain the gallic acid, the tin may be separated by sulphurated hydrogen gas. The sulphurated oxyd falls down in the form of a brown powder. The liquor is to be filtered, after exposing it for some days to the rays of the sun, in order to dissipate or decompose the excess of sulphurated hydrogen gas. It is to be afterwards evaporated in a silver dish, so as to make the gallic acid crystallize by cooling. The liquor which remains is to be washed with a little water, and again evaporated, till all the acid is obtained.

The tannin is separated from the tin, by dissolving the precipitate in a certain quantity of water, and by passing through it a current of sulphurated hydrogen gas. The metal is precipitated, and the pure tannin remains dissolved in the water. When filtered and evaporated, it assumes the deep colour and the peculiar odour of a decoction of nut-galls. The taste of the solution is astringent, and bitterish, but not disagreeably so. It frothes like soap water, but, without being unctuous to the touch, becomes muddy by cooling, and deposits a powder of a bright brown colour, which is redissolved by heat.

By evaporation, this solution affords a dry, friable, brownish substance, which has the vitreous fracture of aloes, and does not attract humidity from the atmosphere. This substance dissolves in cold, and still more readily in warm water.

All acids, by uniting with tannin, precipitate it from its solution in water.

The magma produced by pouring tannin into a solution of glue, possesses the elastic properties of the gluten of farina. By drying it, a brown mass is obtained, vitreous in its fracture, not susceptible of putrefaction, perfectly insoluble in water, and nearly so in alcohol; but capable of resuming its elastic properties, and of becoming soft in warm water.

Albuminous liquors are precipitated by the tannin; but the magma produced does not unite to form a tenacious mass.

The green sulphat of iron is not altered by the tannin, any more than by the gallic acid; but the red sulphat is precipitated, of a pale blue colour, which becomes black by drying. This precipitate differs from the gallat of iron, by not remaining suspended in water, and by being decomposable by acids. If too large a quantity of the red sulphat of iron be poured into a solution of the tannin, the precipitate is redissolved by the uncombined acid, and a black liquor formed of the greatest intensity, which becomes blue by dilution. To separate the precipi-

tate, it is necessary to saturate gradually the excess of acid with potash. During this process, the red sulphat is changed into the green; the oxygen, which forms the difference between these sulphats, being taken from the red sulphat by a portion of the tannin. The tannin, thus oxydated, becomes incapable of precipitating the red sulphat, and remains in the solution. The oxydation of the tannin is also speedily produced by the oxygenated muriatic acid. The gallic acid undergoes a similar change, from the action of the oxygenated muriatic acid, and becomes incapable of precipitating the red sulphat. This is the effect that time produces on ink; the gallic acid in this substance is destroyed, and the red oxyd remains, which may be changed to blue by the method recommended by Mr. Blagden. *An. de Chem.* Tom. XXV. p. 225.

Tannin precipitated by muriatic acid from a decoction of nut-galls, possesses all the tenacity of the substance which is formed by the combination of tannin with glue.

With potash, the infusion of tannin is converted into a substance resembling vegetable jelly.

The nitric acid precipitates at first the tannin, but immediately redissolves it. The solution emits the smell of peaches, and has a red colour.

Sulphuric acid precipitates the tannin, from its solution in water, of a white colour. The flocks do not, as with muriatic acid, immediately form a tenacious mass: but this effect is readily produced by pouring on them a quantity of hot water. *Puschkin, Ann. de Chem.* Tom. XXV.

^b Richter has proposed a shorter process for obtaining the gallic acid. It consists in evaporating the decoction of nut-galls to the consistence of honey, and in dissolving the decoction, thus thickened, in alcohol. The solution is to be filtered, and subjected a second time to evaporation. During this process, crystals of gallic acid are gradually deposited. *Crell's An.* 1787. B. I. f. 139.

Dize has proposed a still shorter, but a more expensive method of obtaining this acid. Rectified sulphuric ether is to be poured on nut-galls, reduced to a powder, and after some time the infusion is to be introduced into a retort, and exposed to a gentle heat. The ether passes over very pure into the receiver; the residue in the retort exhibits all the characters of the resino-extractive substance of Rouelle, with the colour and friability of a resin. This matter does not attract humidity from the air. It forms a coloured solution, in warm water, of an astringent taste. Sulphuric acid is to be added to the liquor, till it acquires an acid taste; a resinous matter is separated; and after a few hours, the liquor is to be diluted with half its weight of water, filtered and evaporated to about 3-4ths. Pure barytes is then to be added, till the liquor ceases to decompose the muriat of barytes. This liquor filtered anew, and subjected to a very slow evaporation, affords very fine prismatic crystals of gallic acid. My intention, says this author, was to point out a process by which the gallic acid may be obtained entirely disengaged from that astringent matter which forms a great part of the weight of iron, when we precipitate it by means of this acid. *Journ. de Phys.* 1791. Part II. p. 420.

^c Proust remarks, that pure green sulphat of iron does not become immediately black with gallic acid. The contact of the air, however, soon colours the surface of the liquor; and the same effect may be produced throughout the whole mass of liquor, by adding a few drops of the oxygenated muriatic acid. It is only when iron is oxydated to its maximum, that it forms an ink with the gallic acid. The black colour can easily be destroyed, by adding to the liquor a solution of sulphurated hydrogen gas. The basis of ink, and of every black dye, is

a gallat of iron, the iron of which is in its highest degree of oxydation. *An. de Chem.* Tom. XXIII. p. 99.

^d Bartholdi observed, that the red oxyd of mercury acquired a blackish colour, by boiling it for half an hour in a solution of gallic acid. This black substance being collected and dried, was subjected to trituration. Fluid mercury was formed during this process, and a carbonaceous powder, which appeared to come from the decomposed gallic acid. During the ebullition, much carbonic acid gas was disengaged; and the solution, which was of a straw colour, became very brown. The solution, after being treated in this manner with red oxyd of mercury, afforded no longer any blueish precipitates with the carbonats of potash and soda. *An de Chem.* Tom. XII. p. 294.

^e Seguin remarks, that a yellow precipitate is formed, after some days, in the infusion of oak-bark. By drying this precipitate, it forms a very fine light powder of a cineritious colour, which is insoluble in water, oil, alcohol, and ether. It burns on lighted charcoal with a thick smoke. Distilled in close vessels, it gives out a large quantity of carbonic acid gas, an acid phlegm, and a brownish coloured oil. A light, spongy, carbonaceous mass remains in the retort. This precipitation takes place in close vessels. If the liquor be exposed to the air, it is covered with a pellicle, which thickens daily. When broken, it falls to the bottom, and forms the precipitate. If the vapour of oxygenated muriatic acid be brought into contact with this infusion, the pellicle is immediately formed; and if the experiment be continued, the pellicle thickens gradually, and falls at last to the bottom as a precipitate. The formation of this precipitate seems, therefore, to depend on the absorption of oxygen. These phenomena are peculiar to all the infusions and decoctions of vegetables. The coloured pulverulent deposit called *Fecula*, is of this kind. It is to its combination with oxygen that it owes its insolubility in water, and by which it seems to approach to the nature of the ligneous fibre.

The infusion of tan, after some days, in hot weather, assumes a vinous smell; but it neither ferments nor putrifies.

Nut-galls.—In distilling the aqueous extract of nut-galls, Deyeux observed, that the extract melted at first; but that, by increasing the fire, a large quantity of carbonic acid was disengaged, and a sublimat formed in the neck of the retort, sometimes in the shape of small needles, and at other times of small scales. This sublimat was afterwards dissolved by a fluid, which was condensed, and passed over into the recipient. When the retort had become almost red, a small quantity of a thick oil was disengaged, which formed a blackish covering in the neck of the retort. The gas which passed over took fire by the flame of a candle.

The liquor in the receiver had an amber colour and a strong acid taste. It produced an effervescence with alkalis. By spontaneous evaporation, it deposited crystals of gallic acid, soiled with a little oil. The sublimate also appeared to be gallic acid.

Two drachms of carbonat of potash were added to 8 ounces of the infusion, and to as much of the decoction of nut-galls. These liquors soon deposited a copious whitish precipitate. Carbonat of ammoniac produced the same effect. The caustic alkalis produce only a very inconsiderable precipitate, and that from the carbonat which they contain; for, if to a mixture of caustic alkali, and of infusion of nut-galls, carbonic acid be added, a copious precipitation takes place.

This precipitate, when washed and dried, had no sensible smell or taste.

Water and alcohol appeared to have only a very weak action on this substance. By long digestion, these fluids become coloured and acquire the property of form-

ing ink with a solution of sulphat of iron. It is soluble in concentrated acids, and in alkalis with the assistance of heat. In a temperature above that of boiling water, it loses its transparency, swells, becomes blueish, and is at last converted into charcoal.

In a retort, this precipitate gives out vapours which are condensed with difficulty, some crystals of gallic acid, and a little empyreumatic oil. The carbonaceous residue, which is very little diminished in weight, burns in the open air, and affords ashes which contain a little calcareous earth but no alkali.

This substance appearing to Deyeux to be somewhat analogous to resin, except only in being soluble in acids, he conceived, that in the infusion it was combined with the gallic acid, which it abandoned, by the addition of an alkaline carbonate. A mixture of pure gallic acid and this precipitate were boiled in water which dissolved them. By adding to this solution an alkaline carbonate, a precipitate took place of the same kind with that employed. It was impossible any longer to doubt that this matter in nut-galls was combined with an acid.

The infusions in which this precipitation were formed, are those of a yellow colour; they become green in the open air, red by an acid, and green again by alkalis. These colours are destroyed by concentrated nitric acid.

By evaporating the liquors of a green colour, a dry matter is obtained soluble in alcohol, and which forms ink with a solution of sulphat of iron.

The solution of this substance in water, was decomposed by oxygenated muriatic acid, and a brownish coloured substance separated, insoluble in water, but soluble in spirit of wine.

The matter from evaporation, when distilled in a retort, afforded an amber coloured liquor containing gallic acid and ammoniac. The carbonaceous residue afforded by combustion, fixed alkali and calcareous earth.

The green colour appears only when the liquors are exposed to the air. It may be produced by passing oxygen gas through the yellow liquors.

Alcohol in digestion with nut-galls acquires a brown colour, but by repeated affusions it ceases to be coloured. If the residue be boiled in water, a true extract is obtained by evaporation. This aqueous decoction affords neither a precipitate with alkali, nor ink with a solution of iron.

The tinctures of nut-gall decompose the sulphat of iron.

Alkalis increase the intensity of their colour, and render them more transparent. Alkaline carbonates, on the contrary, produce a copious white precipitate, and the liquor which swims above speedily acquires a green colour.

The tincture of nut-galls evaporated, leaves an extract soluble in water, even without the assistance of heat. When subjected to the same experiments with the aqueous infusion or decoction, it afforded the same results, except that it was not covered with mould, nor was disturbed by exposure to the air.

Ether acts more feebly on nut-galls than spirit of wine.

The matter of nut-galls dissolved by water, Deyeux conceives to be of a very mixed nature, consisting principally of an extractive body, a particular resin, gallic acid, and a mucous substance. They exist in a state of combination, so as to be equally soluble in water and alcohol. The mucous matter has not been exhibited alone, but its presence is proved from the production of the mould.

Deyeux conceives that the astringent principle results from the union of these parts, and is not possessed by any of them singly. The gallic acid, when very pure, does not possess the astringent quality.

Distilled with water, nut-galls afford a colourless, almost insipid liquor, which does not produce any change in a solution of sulphat of iron.

If boiling water be added to the nut-galls and distilled, the liquor which comes over is coloured, has a taste, and after a certain time deposits a mucous matter. It alters the colour of sulphat of iron, and reddens tincture of turnsole. A heat, therefore, equal to that of boiling water is required to separate the volatile parts from nut-galls.

Eight ounces of nut-galls were distilled in a heat gradually augmented. In a heat nearly equal to boiling water, some drops of a liquid came over, with large and copious bubbles of carbonic acid. The distillation lasted eighteen hours. The liquor in the receiver reddened tincture of turnsole, and produced a black precipitate in the solution of sulphat of iron. By spontaneous evaporation, it deposited silky crystals which were not perfectly pure. The distillation was recommenced; carbonic acid gas came over in large quantity, and a sublimate in very fine white needle shaped crystals was formed in the neck of the retort. This sublimate disappeared by increasing the heat, being dissolved by the liquor which issued from the retort; when the heat was diminished, the sublimate re-appeared again.

Towards the end of the distillation, carbonated hydrogen gas was disengaged along with the carbonic acid. In the receiver was found, 1. A citron coloured liquor which was decidedly acid, it reddened tincture of turnsole, effervesced with alkaline carbonat, and gave out the smell of ammoniac. By evaporation, it afforded a saline magma in which needle shaped crystals could be perceived.

2. A light citron coloured oil which had an acid and caustic taste. Alcohol produced a partial solution which formed ink with sulphat of iron.

3. An empyreumatic oil. These products varied according to the degree of heat that was employed.

It seemed to Deyeux that the carbonic acid was chiefly produced by the decomposition of the gallic acid. The elastic fluids form about 3-4ths of the weight of the matter employed.

The sublimate obtained during the distillation of nut-galls, when pure, has an acid but not astringent taste, it reddens the blue infusions of vegetables, and effervesces with alkaline carbonats. It precipitates metallic solutions, and forms ink with a solution of sulphat of iron.

Placed on burning charcoal, it inflames and emits an aromatic smell. Placed on a hot metallic plate, it melts, boils, becomes black, and is converted into charcoal.

Distilled in a retort, it gives out a yellow acid liquor, some of the salt sublimes into the neck of the retort, and a carbonaceous matter is left behind. During the distillation, an aeriform fluid escapes which appears to be purer than atmospheric air. The gallic salt is completely decomposed by repeated distillations, but this may be effected more easily by distilling the solution of this salt in water. Distilled a fifth time, this solution contained no longer any gallic salt. Though very acid, it gave a green colour to the solution of sulphat of iron. It produced no effervescence with potash or soda, but the liquors became yellow and lost their transparency. Evaporated slowly, regular brownish crystals of a disagreeable taste were formed. These crystals were decomposed in a heat above that of boiling water, and left the alkali at the bottom of the vessel. It appears then that the gallic salt or gallic acid,

1. Is composed of carbon and oxygen not very intimately combined together, for in subjecting it to a moderate heat, oxygenous gas is given out, and carbon left behind.

2. That by parting with a portion of its radical, a new acid is formed.

3. That the gallic acid contains much carbon, the carbonic only a very small quantity.

4. That the gallic may be converted, as in the distillation of nut-galls, into the carbonic acid.

5. That gallic acid differs from the other vegetable acids in containing only carbon for its basis.

By boiling a solution of sulphat of iron with a given quantity of nut-galls, a more copious precipitate is formed, than in the cold, and the liquor contains less sulphat of iron. If to a solution of sulphat of iron, precipitated by nut-galls, a diluted acid be added, the liquor becomes transparent and the precipitate is dissolved, but by saturating the acid with an alkali, and presenting again the nut-galls the precipitate is reproduced. How is the phenomenon produced?

The precipitates by nut-galls from sulphat of iron, produced an effervescence with alkaline carbonat, and communicated a blue colour to water.

Distilled in a retort, they gave out a gas purer than atmospherical air, and concrete gallic acid was sublimed; a very friable black residue was left, which was insoluble in acids. In a red heat, carbonic acid was evolved in great quantity.

If the precipitates be washed or digested with alcohol instead of water, the alcohol acquires an amber colour, it reddens tincture of turnsole, and precipitates the solution of iron. By evaporation, it affords a residue which has all the properties of the gallic acid. Alkaline carbonat now no longer produces an effervescence with this precipitate.

All the acids dissolve more or less of the unwashed precipitate. The nitric acid changes it into a yellowish red acid, while much heat and nitrous gas are disengaged.

On burning charcoal, these precipitates afford an ochreous powder.

If instead of the infusion of nut-galls, we add a solution of gallic acid to the sulphat of iron, the precipitation takes place sooner and more completely, but no purple colour is produced, for the solution contains no colouring matter. It appears, therefore,

1. That the blue colour which water acquires, is owing to a body united to the precipitates, for they become black when it is evaporated.

2. That this blue matter is not very soluble in water.

3. That this blue matter is a gallat or saline substance, for in distilling we obtain the same products as from gallic acid.

4. That the base to which the gallic acid in this substance appears to be united, is a carbonated oxyd of iron.

5. That alcohol appears to decompose the gallat of iron.

6. That fixed alkali has a stronger affinity for gallic acid than the base of the colouring matter.

7. That the matter remaining after the ablutions with water and alcohol, is a true carbonated oxyd of iron.

Gallic acid is the only constituent part of nut-galls which decomposes the sulphat of iron.

The precipitates with the infusions of nut-galls, always contain a certain quantity of resinous and colouring matter.

The iron seems to owe its black colour to the carbon which is furnished by the gallic acid during the precipitation.

The gallic acid in oak bark is in a state different from that in nut-galls.

Hauffman, *Ann. de Chem.* Tom. X. p. 326, asserts, That if carbonat of lime be added to an infusion of nut-galls, or of sumach in ebullition, a large quantity of

carbonic acid is disengaged, and that if, after this, bodies impregnated with alumine be introduced into the infusion, it gives to them yellow shades and a brownish instead of a black colour to the solution of iron.

Sumach.—The repeated and filtered decoction of half a pound of sumach were evaporated by Bartholdi to 2 pounds. A yellowish powder was deposited in cooling. By evaporating it again to 4 ounces, more precipitates were formed. These precipitates dissolved readily in warm water, and partially in alcohol. These solutions precipitated of a black colour the solution of iron. 6 gros of nitric acid were poured on 50 grains of these precipitates; no gas was extricated in the cold, but with heat much nitrous gas and carbonic acid. The red colour disappeared during the boiling, and 3 grains of sulphat of lime was deposited. By continuing the evaporation, a precipitate was formed which possessed all the properties of oxalat of magnesia. By treating this successively by quick lime, muriatic acid, and carbonat of potash, 13 grains of white magnesia were obtained. From this liquor also, 4 grains of the malat of lead was obtained by adding a solution of nitrat of lead.

Bartholdi saturated a solution of 20 grains of gallic acid with carbonat of magnesia, and during the saturation, much carbonic acid was disengaged. This salt, was in every respect the same as that from the decoction of sumach.

The decoction from which the gallat of magnesia had been separated, was evaporated to the consistence of an extract which weighed 1 ounce 2 gros. Boiled in 4 ounces of alcohol, 3 gros were dissolved. The alcoholic solution deposited, by cooling, 15 grains of nitrat of potash and a brownish matter, which, when dry had all the properties of gallat of magnesia mixed with the sulphat of lime. The residue dissolved in water, afforded 30 grains of muriat of soda in regular crystals; the remaining liquor was alkaline. Saturated with acetic acid, it gave 4 grains of acetit of potash, and 3 grains more of muriat of soda. The residue now weighing 26 grains, was boiled in 40 ounces of distilled water, 6 grains were dissolved which appeared to be sulphat of lime. Magnesia was precipitated from the ashes of the residue which had been burnt in a crucible.

The matter which had not been dissolved in the alcohol weighed 7 gros. It had a mucilaginous, bitter, and saline taste. The solution of this substance coagulated in the cold by the addition of acids, and exhibited the same appearances as a mucilage in the fire. From the ashes, 6 grains of carbonat of potash, and 16 grains of sulphat of potash were obtained; a part of the last seemed to come from the decomposition of the sulphat of lime. By boiling what the cold water did not dissolve, Bartholdi obtained 6 grains of sulphat of lime, and by treating with nitric acid and carbonat of potash, 6 grains of carbonat of lime, and 7 of carbonat of magnesia were obtained.

Bartholdi remarks, *Ann. de Chem.* Tom. XXX. p. 263, that an infusion of the bark of the white willow decomposes lime water, and the greater part of earthy and metallic salts.

Sulphat of commerce is not attached at first, but after some time, a greyish precipitate is formed, and the liquor retains its yellow colour.

Animal substances which are disposed to putrefy, are preserved a long time by keeping them in this infusion, and seem to pass rather to the fermenting than putrefactive process. Both the white and yellow parts of an egg are coagulated by their infusion, but the magma does not form a tenacious mass.

This decoction produces a precipitation in a decoction of starch. A solution of soap in one part of alcohol and two of water, is decomposed by this decoction. While one portion of the astringent principle combines with the alkali, and remains

dissolved in the water, another portion unites with the oil of the soap, and forms a compound, insoluble in that fluid.

If an acid be added to the combination of the alkali and astringent principle, it seizes upon the alkali, and the astringent principle is separated in a pulverulent form.

Powder of charcoal boiled in this decoction, did not produce any change in its colour or other properties.

BENZOIC ACID.

With potash, the benzoic acid forms a neutral salt, shooting into pointed thin crystals, which are easily soluble in water, have a sharp, sweetish, saline taste, a suffocating smell, and deliquesce in the air; but, with excess of acid, this salt is not deliquescent. The acid flies off with heat.

With soda, this acid forms an efflorescent salt, which resembles much the benzoate of potash in its form and other properties. This salt, according to Trommsdorff, is decomposed by potash.

Ammoniac crystallizes with benzoic acid into a salt of a very pungent taste, easily soluble in water, and which attracts moisture from the atmosphere. It is decomposed by fixed alkalis, and easily volatilized by heat.

Benzoate of lime shoots into pointed plumose radiated crystals. This salt is not so soluble in water as the alkaline benzoates. The acid is volatilized by the fire. Bergman and Trommsdorff affirm, that lime water decomposes the alkaline benzoates.

The solution of the magnesian benzoate affords short, feathery crystals, which are very soluble in water, effloresce in the air, have a sharp bitterish taste, and are decomposed by fire. Lime water, and the caustic alkalis, decompose this salt.

Benzoic acid unites readily with aluminous earth, and forms with it a crystalline mass, which has a weak astringent taste. It is decomposed by alkalis, lime, and magnesia.

Barytes forms with benzoic acid a salt difficultly soluble in water, which crystallizes in fine needles, and has a bitterish suffocating taste.

TARTARIC ACID.

TARTARIC acid exists naturally not only in the juice of grapes, but also in those of tamarinds, in the berries of the *rhus coriaria*, and in the leaves of the *rumex acetosa*. Hermbstadt found it combined with calcareous earth, in the expressed juices of the roots of the *triticum repens*, *leontodon taraxacum*, and in the *cinchona officinalis*.

Mr. Schiller proposes to obtain the pure acid of tartar, by dissolving one pound of cream of tartar in about 6 pounds of boiling water, to which a quarter of a pound of concentrated sulphuric acid is to be gradually added. By boiling the liquor till one half of this evaporated, the sulphate of potash will be precipitated. The evaporation is to be continued till it acquires the consistence of a syrup. The liquor then deposits the tartaric acid by cooling.

By treating 6 drachms of the tartaric with nitric acid, Hermbstadt obtained 4 drachms and 2 scruples of the oxalic acid.

According to Weftrumb, the tartaric may be converted into the acetic acid, by digestion in water and alcohol.

Tartaric acid dissolves magnesia only when it is in excess. The salt, in solution, shoots by evaporation into small polygonal transparent crystalline grains, which approach more or less to the form of six sided prisms, with truncated pyramidal terminations. These crystals are much more soluble than the tartaric of lime, and have a more saline taste. The acid of this salt is decomposed by heat.

Alumine forms an astringent solution with this acid, which does not crystallize; but, by evaporation, it yields a clear, transparent, gum-like mass, soluble in water, which does not deliquesce in the air.

Barytes forms, with excess of acid, a salt easily soluble in water. This earth takes tartaric acid from the alkaline tartarites.

Concentrated sulphuric acid, according to Gren, decomposes the tartaric acid. Sulphureous acid gas is disengaged, and the tartaric converted into acetic acid. *Gren's Handbuck Weinslein.*

CHAPTER VII.

CONCERNING THE VEGETABLE ACIDS FORMED BY THE ACTION
OF FIRE, AND BY THAT OF THE NITRIC ACID.

IT has long been known in chemistry, that many vegetable substances afford acid phlegms or liquors by distillation; but sufficient attention has not been paid to these saline substances, altered by fire. Since the discovery of so many acids, really differing from each other, whether by their intimate nature, or by a modification relative to the proportion of their principles, many of these salts have been observed to possess distinctive and particular properties. It has likewise been found, that some acids act upon vegetable matters in the same manner as heat, and that the nitric acid converts most of them into acids. In order to know these saline substances, whether new or modified, it will be necessary to examine them with care. We must first observe, that the vegetable acids, formed by the action of heat, must possess an analogy of nature or formation; it is on account of this analogy that we distinguish them by the generic names of empyreumatic acids; and to specify each of them, we prefix the word *pyro* to the expression, which indicates its origin; thus we say, the *pyro-tartarous*, *pyro-mucous*, and *pyro-lignous* acids.

§ 1. *Concerning the Pyro-tartarous Acid.*

We have already observed, that, in the distillation of the tartarous acidule, an acid phlegm is obtained, which is not the pure acid of that substance, but the salt altered in a peculiar manner. The hydrogen gas and the carbonic acid gas, which are disengaged at the same time, sufficiently announce this alteration, because it is at the expence of the principles of the acid of tartar that they are formed. As it is from heat that this alteration of the tartar arises, and as there is an oil driven up together with the distilled acid, which modifies the colour of this last, we have called this acid *pyro-tartarous*, and its saline combinations *pyro-tartarits*, according to the rules of the methodical nomenclature.

The first chemists who conducted their researches with some accuracy, determined, that by distillation they obtained one fourth of the weight of the tartar, consisting of an acid phlegm of a very penetrating smell, which was the pyro-tartarous acid. The rectification, or second distillation of this acid, which has been recommended by a great number of authors, exhibits a very great difficulty, according to the academicians of Dijon, namely, that the rapid elevation of the liquid always burst the vessels, in spite of every care they took to moderate the heat, and leave room for the vapours. They attribute this elevation to the gas produced by the decomposition of the acid, and compressed by the oil, against the pressure of which it prevails at last by its great dilatation. However, this rectification may be dispensed with; and the acid, separated from the oil by means of the funnel, is sufficiently pure to exhibit all its distinctive characters.

The pyro-tartarous acid has an empyreumatic smell and taste; it does not redden violets, but it does turnsole and blue paper; it disengages the carbonic acid from its basis, with a strong effervescence: with earths and alkalis it forms salts, which are very different from those constituted by the tartarous acid. These saline compounds have not yet been examined: it is only known that the pyro-tartarits of potash and of soda are soluble in cold water, and are crystallizable; that it decomposes the nitrat of silver, forming a grey precipitate; that it does not decompose the nitrat of mercury but slowly; that it does not decompose calcareous muriat; and that its neutral salts are decomposed by distillation with the sulphuric acid.

Chemists, before they arrived at the knowledge that hydrogen, carbon, and oxygen appear to be the true principles of all the vegetable acids, which differ from each other only in the proportions, had adopted opinions very remote from truth concerning the acid obtained by distillation from tartar. Vennel affirmed, that it was the acid of nitre. Monnet, upon more positive experiments, imagined this acid to be the muriatic acid, disguised by oil and mucilage. But though Scheele found a small portion of muriatic acid in tartar, yet the cubic form of the neutral salt, produced by adding the pyro-tartar-

ous acid to soda and the precipitation of the nitrat of mercury (two properties, on which Monnet established the identity of the pyro-tartarous acid with the muriatic acid), are not, at present, sufficient to chemists to ascertain this identity; besides which, these experiments did not equally succeed in the hands of the chemists of Dijon. Berthollet, Spielman, and Corvinus likewise did not succeed better. It is, on the contrary, very probable, that the pyro-tartarous acid possesses no other principles than those of the tartarous acid itself; from which it appears to differ only in the quantity of those principles. This modification is proved by the smell, the taste, the want of crystallization, by all the other properties of this empyreumatic acid, and, more especially, by the oil and the gaseous carbonic acid, which is disengaged from the tartarous acidule at the same time as the pyro-tartarous acid is formed.

Sufficient researches have not yet been made on this empyreumatic acid, to determine the order of its chemical attractions with earthy, alkaline, and metallic bases.

§ 2. *Concerning the Pyro-mucous Acid.*

By the name of the pyro-mucous acid, we distinguish that which is obtained from insipid, saccharine, gummy, or farinaceous, &c. mucilages, by distillation, and which Morveau had at first named the syrupous acid. Chemists have long known, that sugar affords by distillation an acid phlegm, which is even of considerable strength. Neuman, Cartheuser, Geoffroy, and Bucquet, made particular mention of this acid, but without ever examining its properties. Schrickel is, of all the chemists, the person who has attended most particularly to this principle of distilled sugar.

By distilling sugar, Schrickel obtained, from 16 ounces, 6 drachms of phlegm, passing in white vapours, and condensed in oily streams, of a penetrating smell of horse-raddish, or roasted bitter almonds, of an acid and bitter taste, and of a yellowish red colour. He rectified it from clay; the acid passed clear, with a mild smell and a sourer taste. The acid, thus purified, did not crystallize; but when exposed to cold, the aqueous part froze, and the portion which remained liquid was much more concentrated.

Morveau has observed, in preparing the pyro-mucous acid by the distillation of sugar, that the bottom of the retort was corroded. He does not attribute this corrosion to the acid, which does not exhibit that property when rectified, or when left a long time in the glass, but to the action and adherence of the carbure of iron, which exists in the residual charcoal left by the sugar, and which he had heated very strongly. This acid cannot be concentrated by the volatilization of the water which is united to it, because it is itself as volatile as that fluid. It is this acid which exists in melasses, and, according to Morveau, renders them deliquescent, and prevents their crystallization.

The pyro-mucous acid, when concentrated by freezing, is very penetrating, and strongly reddens blue vegetable colours. It spots the skin of a red colour, as Cartheuser long since observed; and this spot does not disappear but with the epidermis. It rises totally by the fire, and leaves only a brown trace; it is changed, for the most part, into gaseous carbonic acid and hydrogen gas, by cautious distillation in well-closed vessels; it then affords a coaly residue, more abundant than when it is heated in open vessels: part rises without alteration.

Combined with barytes, magnesia, lime, potash, soda, and ammoniac, it forms neutral salts, which we call *pyro-mucits*, whose properties have hitherto been little examined, but which differ from all the known salts. It disengages the carbonic acid from all these alkaline bases with a strong effervescence.

Though the property of dissolving gold was formerly attributed to the spirit of honey, it appears certain that the pyro-mucous acid does not touch this metal, nor platina, nor silver, nor even mercury; but it may, perhaps, dissolve their oxyds. This acid corrodes lead, and becomes opaque in consequence of the oxyd of this metal which is formed; the pyro-mucit of lead has the form of long crystals: it likewise attacks copper, and becomes green; it dissolves tin, and attacks iron, with which it forms a crystallizable salt.

Its chemical attractions have been determined by Morveau in the following order: potash, soda, barytes, lime, magnesia, ammoniac, alumine, metallic oxyds, water, alcohol.

This empyreumatic acid has not yet been much applied to

use. The spirit of honey, of manna, &c. was formerly used in pharmacy, but this usage has long since been abandoned. The acid obtained by the distillation of melasses is used in some manufactories.

§ 3. *Concerning the Pyro-lignous Acid.*

The distillation of wood, more especially beech, birch, and box, affords a brown acid liquor, of a peculiar smell and considerable strength, which reddens blue vegetable colours, and causes an effervescence with alkaline carbonats. Boerhaave was acquainted with the product of box, guaiacum, juniper, and oak; but the chemists who have repeated the process of Boerhaave have not examined the nature and properties peculiar to this acid. Mr. Goettling is the first who published, in 1779, in Crell's Journal, a memoir on the Acid of Wood, and more especially its union with alcohol. This learned man made use of the bark of birch, which he distilled in an iron retort: the brown and oily acid which he obtained was left at repose for three months; he separated, by the filtre, the drops of oil which arose to the surface, and poured a solution of potash into the liquor. A lively effervescence was produced, the liquor assumed a blood red colour, and after saturation with the alkali, and evaporation, it afforded a black salt, which was melted in an iron ladle, and purified by a second solution and evaporation.

The pyro-lignous acid may likewise be rectified by distillation, according to Mr. Goettling.

The pyro-lignit of potash formed by this rectified acid becomes very hot by the addition of sulphuric acid, and the pyro-lignous acid is disengaged in a state of considerable purity. This chemist, to whom we are indebted for these experiments, has observed, that the pyro-lignous acid, separated by means of the sulphuric acid, lost its empyreumatic smell, but acquired that of garlic.

The chemists of Dijon employed the wood of beech to obtain this acid, which they distilled, and after rectified the liquid product: 55 ounces of this wood in dry chips afforded them 17 ounces of rectified acid, of an amber colour, without mixture of oil, and whose weight, compared with that of di-

stilled water, was in the proportion of 49 to 48 : $23\frac{1}{2}$ ounces of lime water were required to saturate one ounce of this acid. When gently heated, it rises in vapour. A strong heat decomposes it, as well as all the other vegetable acids. It cannot be obtained in the concrete form.

It combines with earthy and alkaline bases, and forms peculiar salts, which we call the pyro-lignits of alumine, of barytes, of magnesia, of lime, of potash, of soda, and of ammoniac. These salts have not been yet examined with sufficient attention to enable us to give a sketch of their history. Mr. Eloy Bourcier de Clervaux has communicated, in the Dijon course of chemistry, experiments proper to determine some of the elective attractions of the pyro-lignous acid. Calcareous earths and barytes adhere more strongly to it than the alkalis; lime more strongly than barytes; and magnesia more strongly than ammoniac: so that the order of these attractions alone might serve to distinguish it from most of the other vegetable acids. It acts on several metals, and dissolves most of their oxyds.

It seems as if all woods would afford the same acid by distillation, since box, birch, and beech have already afforded a similar one. We perceive, however, that a number of experiments remain to be made to complete our knowledge of the properties and distinctive characters of this acid.

§ 4. *Concerning the Vegetable Acids formed by the Nitric Acid.*

Bergman has shown that the nitric acid converted sugar into an acid, which was at first thought to be different from all others, and was distinguished by the name of the saccharine acid. Scheele has shown that this acid is absolutely of the same nature as that which is partly neutralized by potash, in the salt of sorrel: this identical acid is, therefore, at present, the oxalic acid. Several modern chemists, and more especially Berthollet, have proved, that the greatest part of vegetable and animal matters afford this acid by means of that of nitre. It is certain, therefore, that the base, or oxalic radical, exists in a great number of substances, and generally in all those which have been formed by the action of vegetable or animal life. The nitric acid acts in an equal and uniform manner up-

on all these substances ; it always yields to them a greater or less quantity of its oxygen, and passes to the state of yellow nitrous acid, nitrous gas, and even azotic gas, according to the proportion of oxygen which is disengaged. Accordingly, as the base or oxalic radical is more or less abundant in the different organic matters which contain it, a greater or less quantity of this acid is formed by the nitric acid. At the same time that the acid of nitre is decomposed by organic substances, a certain quantity of carbonic acid gas is disengaged, together with the nitrous or azotic gas ; which proves that the organic matter has lost a portion of its carbon, and that the oxalic acid which arises contains less of this principle than the substance which afforded it. Since several vegetable acids, and in particular that of tartar, pass to the state of oxalic acid by the action of the nitrous acid, and since carbonic acid is disengaged during the time this conversion is effected, we see very well, that these vegetable acids have the same radical, and differ only in the proportion of oxygen.

It has been announced in the *Nouvelles de la République des Lettres* for the year 1785, numbers 42 and 44, that Mr. Kosegarten obtained from camphor, by distilling nitric acid, eight successive times from it, a concrete acid, crystallized in parallelepipeds, of a bitter taste, and which reddened the tincture of violets and of turnsole. This salt, according to the chemist we have quoted, differs from the oxalic acid in not taking lime from the muriatic acid : it forms with potash a salt in regular hexagons ; with soda, a salt in irregular crystals ; with ammoniac, prismatic or needle-formed crystals ; and with magnesia, a soluble pulverulent salt. It dissolves copper, iron, bismuth, zinc, arsenic, and cobalt : but these first facts, which have not yet been confirmed, are not sufficient to enable us to treat the properties of this acid in detail ; which, perhaps, is only a modification of some of those we have described. If new researches concerning this acid should discover peculiar properties different from those of all others, its nature will be examined and characters under the name of the *camphoric acid*, and of *camphorats* for the neutral salts.

Brugnatelli discovered in 1787, that cork, upon which he had distilled four times its weight of nitrous acid, left a yel-

lowish thick acid mass, soluble in water, of a sour and slightly bitter taste. This acid is not crystallizable: by a strong evaporation, it is converted into a viscid mass resembling wax, and which, like that substance, may be softened and moulded between the fingers. It is soluble in alcohol; is converted into coal without taking fire upon ignited coals: with the earths and alkalis it forms deliquescent salts, several of which crystallize: Lastly, It has as strong an attraction for lime as the oxalic acid, and forms with it a salt insoluble in water, but soluble in the muriatic acid.

Without making any decision on the peculiar nature of this acid, Brugnatelli seems, nevertheless, to think that it differs from the oxalic acid. New experiments must decide whether this acid be really different, and it deserves to be particularly examined, as well as that which Messrs. Proult and Angulo have discovered near Madrid, on the surface of chick-peas, in the vesicles placed at the extremity of the hairy fibres of this leguminous plant.

Such is the history of all the known vegetable acids: it remains, therefore, only to treat of those which are formed by fermentation; but the best, and indeed the only known of these acids, is the product of an alteration which takes place in liquors already fermented. We shall place its history immediately after that of the spirituous fermentation and its product.

NOTES ON CHAPTER VII.

CAMPHORIC ACID.

THE nature and habitudes of the camphoric acid have been more recently investigated by Bouillon le Grange.

This chemist prepares the camphoric acid, by distilling 4 ounces of camphor in a sand-bath with one pound of nitric acid, at 30° . During the distillation, a considerable quantity of nitrous gas and carbonic acid are disengaged. One portion of the oxygen is volatilized, while the other seizes on the oxygen of the nitric acid. When vapours cease to be disengaged, the vessels are to be unluted, and the camphor which has been sublimed, returned into the retort, and a fresh portion of acid added to it. The process of distillation is to be repeated in this manner, till the whole of the camphor is converted into an acid; 4 pounds 14

ounces of nitric acid are required to acidify 4 ounces of camphor. The most certain mark of complete acidification, is the crystallization of the liquor which remains in the retort. This acid is purified, by dissolving it in warm water, filtering the solution, and evaporating it till a thin pellicle forms on the surface; the camphoric acid then crystallizes by cooling.

The camphoric acid may be formed more speedily, by using a stronger nitric acid. But in this case a portion of the camphor is lost, by being dissipated along with the gases.

Camphoric acid effloresces in the air, and dissolves difficultly in cold water. An ounce of this fluid, in the ordinary temperature of the atmosphere, is required to dissolve 6 grains of camphoric acid; but the same quantity of boiling water dissolves 48 grains. This acid is wholly dissipated on burning charcoal, emitting a thick aromatic smoke. In a more gentle heat it melts, and is sublimed. Some of its properties are changed by this sublimation, for it no longer reddens the tincture of turnsole, and becomes insoluble in water, and in sulphuric and muriatic acids. Warm nitric acid dissolves it, as does alcohol. If the alcoholic solution be exposed to the air, the acid crystallizes.

Camphoric acid has no action on sulphur. It is soluble in the mineral acids, in alcohol, and in the fixed and volatile oils. This acid is distinguished by its crystallization, by its difficult solubility in cold water, by burning without any residue, by not precipitating lime water, and by forming particular neutral salts, which all emit a blue flame with the blow-pipe.

Camphoric acid unites readily with earths and alkalis. When pure, the salts which it forms have no odour.

Camphorat of potash is prepared, by adding crystallized camphoric acid to a solution of carbonat of potash. When the effervescence ceases, the liquor is to be evaporated with a gentle heat. During cooling, crystals of camphorat of potash will be obtained. This salt exists in the form of a regular hexagon; it is white, transparent, and has a bitterish, slightly aromatic taste. The acid is dissipated by a weak, and decomposed by a strong heat. Camphorat of potash loses its transparency in a moist air. Four parts of boiling water dissolve one of this salt; while water of the ordinary temperature dissolves only rooth part. It is soluble also in alcohol, and the solution burns with a blue flame. Camphorat of potash is decomposed by lime. The mineral acids decompose this salt; but the vegetable acids have no very evident action on it. Camphorat of potash is decomposed by all the salts with bases of lime. It is decomposed also by the nitrat of silver the sulphat of iron, and the muriats of tin and of lead.

Camphorat of soda is obtained in the form of white, transparent, irregular crystals, which have a bitterish taste. The acid may be dissipated or decomposed according to the degree of heat to which it is subjected. It effloresces a little in the air. Boiling water dissolves 1-8th; water of the ordinary temperature only 1-200th of its weight of this salt: It is wholly soluble in alcohol. Lime decomposes camphorat of soda; not so potash. It is decomposed also by the mineral acids. It decomposes the nitrat of lime, the muriats of magnesia, barytes, alumine, and lime, and the sulphat of alumine. Many of the metallic solutions are also decomposed by this salt, such as the sulphats and nitrats of iron, and the nitrat of silver.

Camphorat of ammoniac is obtained by evaporation, in an opaque and slightly bitter, crystalline mass. It is volatilized by heat, and becomes moist in the air. Three parts of boiling water dissolve one of the salt; but, in the ordinary temperature of the atmosphere, only about 1-100th: It is soluble in alcohol. The camphorats become also much more soluble by an excess of alkali.

Lime and barytes, potash and soda, decompose the camphorat of ammoniac, as do also the mineral acids. The greater part of the calcareous salts form triple combinations with camphorat of ammoniac: It decomposes only in a partial manner aluminous salts and metallic solutions.

Camphorat of lime has no regular figure: When perfectly neutralized it is of a white colour, and has a bitterish taste. It melts in a gentle, but its acid is decomposed in a strong, heat. It is very insoluble in water, requiring about 200 parts of that fluid in a boiling state to dissolve one of it. Camphorat of lime is not decomposed by any earth or alkali: It is decomposed by the mineral acids, by carbonat of lime, by the nitrat of barytes, muriat of alumine, fulphat of alumine, and phosphat of soda. The oxalic, tartarous, and nitric acids decompose the camphorat of lime. It is insoluble in alcohol, and contains in the 100, 43 of lime, 50 of camphoric acid, and 7 of water.

Camphorat of Barytes.—The camphoric acid acts on barytes only with the assistance of heat. It is obtained in the form of small thin plates, which have no regular figure. They have a slightly acid taste, mixed with bitterness. Its acid may be dissipated or decomposed by the fire; 600 parts of boiling water are required to dissolve one of the salt: Camphorat of barytes is decomposed by lime, potash, and soda. It is decomposed also by the mineral acids, and by the oxalic, tartarous, and citric. The nitrats of potash, soda, lime, ammoniac, and magnesia decomposes this salt. The muriats of lime, potash, alumine, and magnesia, produce the same effect. It is decomposed by all the sulphats: Some of the results are triple combinations. Camphorat of barytes is very insoluble in alcohol.

Camphorat of Alumine.—Alumine unites difficultly with the camphoric acid. The salt which it forms is of a white powdery substance, has a slightly bitter, acid, and a strong astringent taste. It reddens the blue vegetable infusions. It burns like the other camphorats with a blue flame. It seems disposed to effloresce. It requires 200 times its weight of water to dissolve this salt: Boiling water dissolves it readily. It is decomposed by lime, barytes, potash, soda, and ammoniac; it is decomposed also by the mineral acids, and by the oxalic, tartarous, citric, and acetic. The nitrats of lime and barytes decompose this salt. The decomposition with the muriats is incomplete, triple combinations, being formed. This salt is more soluble in warm than in cold alcohol. The alumine is deposited upon cooling, but the acid remains dissolved in the alcohol.

Camphorat of Magnesia.—This salt does not crystallize: It is white, opaque, and has a bitter taste. Heat produces the same effects on it as on the other camphorats. It effloresces slowly in the air. It is difficultly soluble, but more easily so in warm than in cold water. It is decomposed by all the other earths, and by the alkalis. It is decomposed also by the mineral acids, and by the acetic, oxalic, nitric, and tartarous. The nitrat of lime, and the muriat of alumine, are the only salts which produce a complete decomposition of the camphorat of magnesia. Alcohol dissolves this salt with the assistance of heat, but the alumine is deposited by cooling. The addition of water prevents the precipitation of this earth. It is a general fact, Lagrange remarks, that this acid is never precipitated from its solution in alcohol by water, a circumstance which distinguishes this acid from the benzoic. *An. de Chem.* Tom. XXIII. p. 153. Tom. XXVII. p. 19.

SUBERIC ACID.

BOUVILLON LAGRANGE has published some new experiments and observations on the suberic acid, in the XXIII. volume of the *Annales de Chemie*.

Six parts of nitric acid are to be distilled by a gentle fire, with one part of the raspings of cork; nitrous vapours are disengaged, the cork swells and assumes a yellow colour; and, in proportion as the distillation advances, it sinks. When the froth, which is formed, ceases to appear on the surface of the liquor, the acid which had passed over into the receiver is to be returned into the retort, and the distillation repeated till no more red vapours are produced. The retort is then to be taken from the sand-bath, and while it is still warm, its contents are to be poured into a glass or porcelain cup, which is placed on a sand-bath, and exposed to a very gentle heat. The mixture, which is to be constantly stirred with a glass rod, gradually thickens; and as soon as white vapours are observed to be disengaged, the mixture is to be removed from the sand-bath, and stirred carefully till it cools. During the distillation of 1 drachm of cork with 6 of nitric acid, 113.63 inches of gas were disengaged; of this about 40 cubic inches were carbonic acid, and the rest nitrous gas.

The yellow saline mass is now to be mixed with twice its weight of water, melted with a gentle heat and filtered. The liquor which passes through the filtre, is of a clear amber colour, and has a peculiar smell somewhat similar to that of prussic acid. It becomes muddy by cooling, is covered with a saline pellicle, and deposits a pulv. rulent sediment.

The precipitate is to be collected and dried with a gentle heat, and the liquor evaporated till the acid which it contains be all deposited. This acid is obtained by precipitation in a pulverulent form, and by evaporation in thin irregular pellicles. Dissolved in a small quantity of boiling water, it stimulates the throat and excites coughing.

Suberic acid reddens blue vegetable colours and attracts humidity from the air, particularly when impure. It becomes brown by exposure to light. Heat volatilizes it. By exposing it to the blow-pipe, this acid emits the smell of the sebatic acid.

When very pure, an ounce of water dissolves only 4 grains of suberic acid. Boiling water dissolves nearly half its own weight, which it deposits again by cooling.

The other acids have little action on this acid. A kind of ether may be obtained from it by distilling it with alcohol.

It decomposes the acetit and nitrat of lead, and gives a green colour to the nitrat of copper. It decomposes also the nitrats of mercury and silver, together with the sulphats of copper, iron, and zink.

The *suberat of potash* forms prisms with four unequal sides. It has a bitter saltish taste, and reddens blue vegetable colours. It swells with heat, and parts readily with its acid. It is very soluble in water. Suberat of potash is decomposed by barytes, and by the mineral acids. All the metallic solutions are decomposed by this salt. It decomposes also the sulphat of alumine, the muriats of alumine and lime; the nitrats of lime and of alumine, and the phosphat of alumine.

Suberat of soda is not obtained in a crystallized state; it has a slightly bitter taste, reddens tincture of turasole, and attracts humidity from the air. It is soluble in alcohol, and is decomposed by the fire, by barytes, and by potash. Mineral acids precipitate the suberic acid. Suberat of soda decomposes calcareous, magnesian, and aluminous salts.

Suberat of ammoniac has a saltish taste, which at last becomes bitter. It attracts humidity from the air, and reddens blue vegetable colours. It is volatilized without any remainder by an intense heat; water dissolves it readily. Barytes, the

fixed alkalis, and lime decompose it, as do also the mineral and oxalic acids. It decomposes the aluminous and magnesian salts.

Suberat of barytes is not crystallizable. It swells and melts by the action of heat, and is soluble in water, with an excess of acid. It is not decomposed by alkalis, but the mineral and oxalic acids take from it its basis. It decomposes all the salts, except the fluat of lime and barytic salts.

Suberat of lime does not crystallize. It has a white colour, a slightly saltish taste, and does not redden the tincture of turnsole. It swells on burning charcoal, while its acid is disengaged. *Suberat of lime* is more soluble in warm than in cold water. Barytes, potash, and soda, precipitate the lime. It is decomposed by the mineral and by the oxalic acids. It decomposes the carbonat of potash and soda, the fluat of magnesia, the phosphat of alumine and soda, together with the borat of potash.

Suberat of magnesia reddens tincture of turnsole, has a bitter taste, is soluble in water, and attracts humidity from the air. It exists in a pulverulent form. It swells and melts by heat. Its acid is decomposed by the blow-pipe. Barytes, alkalis, and lime decompose this salt, as do also the mineral and oxalic acids. It decomposes the muriat of alumine, the nitrats of lime and alumine, the borat of potash, the fluat of soda, the borat of soda, and the phosphat of alumine.

Suberat of alumine reddens tincture of turnsole. It attracts humidity from the air, and is decomposed by an intense heat. The other earths, the alkalis and mineral acids decompose it. It decomposes the sulphat and muriat of iron, the nitrats of silver, mercury, and lead.

The suberic acid has no action on platina, gold, and nickel, but it forms metallic suberats with oxyds of silver, mercury, lead, copper, tin, iron, bismuth, arsenic, cobalt, antimony, manganese, and molybdena. In general, these salts do not crystallize, and have all an excess of acid.

CICERIC ACID.

PROUST, in a letter inserted in the *Journal de Physique* for May 1787, first mentions the existence of an acid liquor on the stalks, leaves, and pods of the pea vetch, or the *cicer arictinum* of Linnaeus. When washed and bruised, this plant did not exhibit any mark of acidity. Proust conceived that it was merely an acidifiable base which exuded from the plant, and which was afterwards converted into an acid by combining with the oxygen of the atmosphere.

Deyeux, who collected this acid liquor, seems inclined to think that the hairs which cover this plant are the excretory organs, in which this acid is formed. From some experiments which he made with a view to discover the nature of the acid, he concludes it to be the same with the oxalic, and considers this plant as the only instance in which pure uncombined oxalic acid is produced. *Journ. de Phys.* An. VII. Tom. III. p. 362.

Dispan, however, who had made a great variety of experiments on this acid, is of opinion, that it differs not only from the oxalic, but from every known acid. He collected the acid liquor by wiping the plant with a clean linen cloth, and by washing the cloth in distilled water, to which it imparts the acid. When the water has acquired a taste sufficiently acidulous, it is to be filtered, and evaporated with a gentle heat to the degree of concentration required. This liquor, according to Dispan, acquires by evaporation a colour which passes gradually from a ci

tron yellow to the colour of Malaga wine. The following are the properties, which this chemist ascribes to the *ciceric acid*.

1. It has a sharp and penetrating taste.
2. It reddens the blue vegetable colours which are sensible to acids.
3. It effervesces with alkaline and calcareous carbonats.
4. It does not form any deposit or mouldiness by age.
5. It preserves its colour and transparency, but loses somewhat of its strength and acidity.
6. It gives a beautiful red carmine colour.
7. It is precipitated by the gallic acid, and gives a beautiful green colour.
8. It forms a kind of syrup by evaporation, and does not crystallize.
9. It becomes brown and brittle like a gum by drying.

Ciceric acid forms with potash a salt which crystallizes in bundles of shining needles turned spirally and parallel to each other. The taste of this salt is cooling, like that of nitrat of potash; but it leaves behind it a saline sharp taste. It dissolves readily in water. It melts on burning charcoal; boils and swells up considerably. The carbonaceous matter which it forms leaves behind it spongy alhes, of a grey colour.

With soda this acid forms a salt which does not crystallize, and which has an austere taste.

Its combination with ammoniac affords, by spontaneous evaporation, transparent shining crystals, of which the form has not yet been determined. A gentle heat decomposes this salt by volatilizing the ammoniac.

Lime produces with this acid a soluble salt, which, by a cautiously conducted evaporation, crystallizes in very large solid polyhedrons, that have some analogy with those of sugar. At first this salt seems to have little taste, but at the end of some time it produces a saline taste. It is reduced to a dry and friable mass by the heat of lighted charcoal. Carbonat of potash and the oxalic acid decompose it.

Magnesia forms with this acid a salt which crystallizes in white grains, the figure of which has not been determined. It has a saline taste, burns readily, and leaves behind it a greyish residue.

The ciceric acid dissolves iron filings with effervescence. This combination, which has a styptic taste, does not crystallize, but it affords a crust by evaporation that is deliquescent. Lime and alkalis decompose this salt, and precipitate the iron of a greenish blue colour, which soon becomes yellow. From these experiments Dispan concludes that the ciceric acid is of a peculiar nature, different from all other vegetable acids; but it seems to be still undetermined whether the acid liquor exuding from the pea vetches contains two different acids, or if the ciceric is a modification of the oxalic acid. *Journ. de Phys. An. VII. p. 302, 409; Ann. de Chem. Tom. XXX. p. 179.*

CHAPTER VIII.

CONCERNING THE SACCHARINE MATTER, GUMS, AND MUCILAGES.

THE saccharine matter, which many chemists consider as a kind of essential salt, is found in a great number of vegetables, and may be properly ranged among their immediate principles. The maple, the birch, the red beet, the parsnip, the grape, wheat, &c. contain it. Margraaff extracted it from most vegetables. The petals of many flowers, and the nectariums placed in those organs, elaborate a principle of this kind.

The sugar cane, *arundo saccharifera*, contains it in larger quantities, and affords it more readily, than any other plant. The ripe canes are crushed between two iron cylinders placed perpendicularly. The expressed juice falls on a plate beneath, and is called *melasses*. It flows into a caldron, where it is boiled with wood-ashes and lime, and the scum taken off. This boiling with ashes and lime is repeated in three other boilers, and converts it into syrup. It is then strongly boiled with lime and alum; and when it is sufficiently concentrated, it is poured into a vessel called the *cooler*. When it is cooled so that the finger may be plunged into it without injury, it is poured into barrels placed over certain cisterns, and pierced at the bottom with many holes, stopped with canes. The syrup becomes solid in the casks, and part flows out through the holes into the cistern beneath. The sugar in this concrete state is yellow and greasy; it is called *muscovado*. It is refined in the sugar islands by boiling, and pouring into inverted earthen cones, called *pans*. That part of the sugar which is incapable of becoming concrete, runs through the aperture of the pan into a pot placed beneath; it is called *coarse syrup*. The base of the sugar loaves is taken away, and white sugar in powder is put in its place, and pressed down; the whole is then covered with moistened clay. The water of the clay filtrates through the sugar, and carries with it a portion of the mother water, which runs out through the aperture at bottom, and is received in other pots; it is called *fine syrup* as being purer than the

former. A second covering of clay is put on when the first is dry, and the water is suffered to filter through a second time; after which, the loaves are carried to a stove to dry. At the end of eight or ten days these loaves are broken, and the powdered sugar is conveyed to Europe, where it is refined into sugar of different qualities.

The process of refining consists in boiling the sugar in lime-water, together with bullocks blood, taking off the skim three or four times, and filtering the liquor, which is then poured into pans to make loaves. The loaves are covered with a stratum of moistened clay, and the water is thus filtered through the sugar, by the repeated addition of a new stratum of clay as the former becomes dry, until the sugar has acquired the requisite degree of whiteness. The loaves of refined sugar are then conveyed into a stove, and at the end of eight days are wrapped in paper, and tied up for sale. The remaining syrup, which cannot be crystallized, is sold under the name of *melasses*.

All chemists formerly supposed that these different operations separate a fat matter from sugar, and by that means render it susceptible of crystallization. Bergman thinks that lime serves to deprive it of that excess of acid which prevents its taking the solid form. This acid can be nothing else but that which is formed by heat, or the pyro-mucous acid we have spoken of in the preceding chapter. As the liquor is quickly evaporated during the whole process, it takes the form of a granulated and irregular mass, in the same manner as we have before observed with respect to the sulphat of zink.

Sugar is a substance holding in some respects an intermediate place between essential salts and mucilages. It possesses the property of crystallizing. It crystallizes in hexahedral truncated prisms, and in this state is called *sugar-candy*. By distillation it affords water, pyro-mucous acid, and some drops of empyreumatic oil; at the same time that a great quantity of carbonic acid gas, and hydrogen gas, holding charcoal in solution, are disengaged. The residue is a spongy light coal, which contains a small quantity of carbonat of potash.

Sugar is inflammable. On hot coals it melts, and swells up very much, emits a penetrating vapour, and becomes converted into a brown yellow matter, called *caramel*. It is very soluble

in water, to which it gives much consistence, and constitutes a kind of saccharine mucilage, called *syrup*. Syrup, diluted with water, is capable of fermentation, and affords ardent spirit.

Bergman has obtained from all saccharine matters, especially sugar, pure oxalic acid by means of the nitric acid. For this purpose, one part of sugar in powder is mixed in a retort with six parts of nitric acid, and a gentle heat is applied. The evaporation is continued for some time after the red vapours have ceased. The solution being suffered to cool, affords white crystals in the form of needles or prisms, which are the concrete oxalic acid. The decanted liquor treated a second time with three or four parts of the same nitrous acid, affords, by a new crystallization, prisms of the same form. The operation is again repeated on the second mother water. An ounce of white sugar, by this process, affords about three drachms of prismatic salt, which is dissolved in hot water, and crystallized by cooling, in order to obtain it in a state of purity.

Sugar is very extensively useful. It is a food which, taken in too large a quantity, is capable of heating the animal system. It is very much used in pharmacy, where it is the base of syrups, lozenges, and other preparations. It is very useful, as a medium to favour the solution or suspension of resins, oils, &c. in water. It preserves the juices of fruits, after they are reduced into a jelly. It may even be considered as a medicine, since it is incisive, aperient, slightly tonic, and stimulant; and there are, accordingly, instances of disorders, arising from obstructions, which have been cured by the habitual use of sugar.

Certain juices, which flow out of plants, have a saccharine taste. Manna and nectar are of this kind. Manna is produced by the leaves of the pine, the oak, the juniper, the willow, the fig-tree, the maple, &c. The ash, which is very abundant in Calabria, Sicily, &c. affords the manna in commerce. It flows naturally from these trees, but is much more abundantly obtained by making incisions in their bark. That which is collected on chips of wood, or small sticks, introduced into the artificial apertures, forms a kind of stalactites, perforated within, and called *manna in the tear*. Manna, in *flakes*, flows on the bark, and contains some impurities. The inferior, *unctuous sort*, contains many foreign substances, and consists of the refuse

pieces of the two former kinds : It is always moist, and frequently adulterated. The taste of manna is sweet, and slightly nauseous. The manna afforded by the larch tree, which abounds in Dauphiny, and that of the alhagi, which grows in Persia, in the neighbourhood of Tauris, are not used : the latter bears the name of *tereniabin*. Manna is soluble in water, and affords, by distillation, the same products as sugar. Treated with lime and white of eggs, it affords a substance resembling sugar ; and, by the process already described, with the nitric acid, it affords the concrete oxalic acid.

It is used as a purgative, in the dose of from one to two, or three ounces ; or in the dose of a few drachms, diluted, as an alterative.

Another kind among the proper juices of plants, is that called *gum*, or *mucilage*. This substance is very abundant in the vegetable kingdom. It is found in a great number of roots ; the young shoots, and new leaves, contain it in large quantities. This principle may be known by its viscous and adhesive quality, when these parts are crushed between the fingers. At the time of the year when the juices are most abundant, it naturally exudes through the bark of trees, and thickens at the surface into gum. Gum is soluble in water, to which it gives a thick and viscous consistence. This solution, known by the name of mucilage, becomes dry, transparent, and brittle, by evaporation.

Gum burns without any sensible flame ; it melts, and boils upon hot coals ; by distillation, it affords much water and pyromucous acid, a small quantity of thick and brown oil, and carbonic acid gas, mixed with hydrogen gas. Its coal is very bulky, and contains a small quantity of the carbonat of potash.

Three kinds of gum are used in medicine, and in the arts.

1. Gum, which flows from the apricot, pear, plumb trees, &c. It is white, yellow, or reddish ; and when well selected, may be applied to the same uses as other gums. A kind of gummy juice, of a beautiful yellow colour, flows from the elm, and is sometimes found in considerable quantities on its bark. I find this gum to be insipid, soluble, viscous, and to possess all the characters of juices of this nature.

2. Gum arabic, which flows from the acacia in Egypt and Arabia. Gum Senegal is of the same nature : it is used in me-

decide as a softening and relaxing remedy; it gives consistence to crayons, and is used in several arts.

3. The gum Tragacanth, which flows from the adragant of Crete; *astragalus tragacantha*. It is administered in the same cases as the foregoing. Its solution is somewhat thicker; and it requires more water to dissolve it than the other gums. Viscous flakes are deposited from its solution.

Mucilages, of the same nature as gums, are obtained from many plants. The roots of mallows, the greater comfrey, the bark of elm, linseed, the seed of quinces, &c. afford viscous fluids, by maceration in water, which, by evaporation, leave true gums. The decoction of these plants is substituted, in medicine, instead of gums.

All these substances, chemically considered, seem, at first sight, to be bodies not much composed, since chemical experiments often exhibit substances, which, by their gelatinous form, seem to resemble gums and mucilages. Yet, from these vegetable products, which seem to constitute an excrementitious humour, are obtained water, liquid pyromucous acid, carbonic acid, an oily principle, and fixed alkali, united to a coaly residue. This residue contains likewise a fixed earth, whose nature is not yet known.

When gums and mucilages are treated with the nitric acid, aided by heat, they afford crystallized oxalic acid. It appears, therefore, that they contain the oily or radical principle, whose combination with the oxygen constitutes this species of acid.

The analogy between mucilage and saccharine matters, is likewise observable in the fumes of burned gum, which in smell resemble that of caramel, as well as by the nature of the products both afford by distillation, and the porosity and lightness of their residual coal. Among fruits which become saccharine, there are some, as for example, apricots, pears, &c. from which, before the time of their maturity, a true gum exudes. The kind of dry mucilage, which we shall hereafter describe, under the name of *amylaceous fecula*, is converted into saccharine matter by germination. These facts, and many others which might be urged, show, that there is a strong resemblance between sugar and gum. The insipid and gummy mucilage may perhaps pass to the state of sugar, by a kind of fermentation. If the fact were established, it would be proper to place this

fermentation before that which Boerhaave has distinguished by the name of *spirituous*; and it would always precede it, whether in the process of vegetation, or in those operations which are artificially made to produce the saccharine taste in barley, &c.

NOTES ON CHAPTER VIII.

SUGAR, GUMS, AND MUCILAGES.

WE are indebted to Mr. Cruickshank for some most interesting experiments respecting the nature and composition of sugar and mucilage. The following account of these experiments is taken *verbatim* from the late valuable work of Dr. Rollo on *Diabetes*, p. 452.

"Sugar has been supposed to be a substance, intermediate between the vegetable mucilages and acids, containing more oxygen than the former, but less than the latter. With a view to ascertain this, and some other facts relative to these substances, the following experiments were made.

"Two ounces of refined sugar were introduced into a retort, and exposed to a heat gradually increased, until its bottom became red hot; there came over into the receiver 8 1-half drachms of a sharply acid liquor, which required 150 grains of a solution of potash to saturate it; this liquor was mixed with a little empyreumatic oil; the charry residuum which remained in the retort weighed 5 drachms nearly. The quantity of gas which escaped during the operation, must therefore have amounted to two 1-half drachms; some of this being collected, was examined, and found to consist of a mixture of carbonic acid gas, and hydro-carbonat.

"Two ounces of gum arabic were introduced into a retort at the same time, and exposed to a heat in every respect similar; the quantity of acid liquor which came over into the receiver, amounted to 7 drachms and 40 grains; this contained a little more empyreumatic oil, but was not so sharp as that obtained from the sugar, and required only 118 grains of the same solution of potash to saturate it; the charry residuum which remained in the retort weighed 3 drachms and 45 grains; the quantity of elastic fluid or gas which escaped during this process, must therefore have amounted to about 5 drachms; it consisted, like the former, of a mixture of hydro-carbonat, and carbonic acid gas, but towards the end of the operation the proportion of hydro-carbonat was more remarkable. From these experiments it would appear, that sugar yields, by distillation, more pyromucous acid than gum, in the proportion of 150 to 118. The residuary charcoal of the sugar likewise exceeded that of the gum; but this may in part be accounted for, from the greater quantity of hydro-carbonat yielded by the latter. As oxygen is now allowed to be the universal acidifying principle, and as the acid produced in both instances (*viz.* the pyromucous) was the same, it may be reasonably inferred, that the sugar which afforded the greatest quantity of acid, contained likewise the greatest proportion of oxygen; for it is probable, that both the carbonic acid, and the hydro-carbonat, were formed from the decomposition of the water, as neither were produced in any quantity till near the end of the ope-

ration; the oxygen, therefore, contained in the former, should not be considered as entering essentially into the composition of either the gum or sugar.

" It is well known, that vegetable mucilage and fecula, are somehow converted into sugar by malting. We conceived, therefore, that it would throw considerable light on this subject, to observe with more attention than had hitherto been done, the particular changes and decompositions which take place during this process. With this view the following experiments were made.

" *December 1st 1796.* A quantity of barley, after being soaked in water for 24 hours, was put into a wine glass, which was introduced into a jar containing common air, and inverted over water. The temperature in this and the following experiments was preserved between 60° and 70° as nearly as possible. At the end of 5 days it began to grow, and on the 28th the greatest part had thrown out shoots at least half an inch in length. On February 7th, vegetation was still going on, and the air in the jar had somewhat diminished; the barley being now withdrawn, was found to be very sweet, and nearly converted into the state of malt. The air in the jar was found to consist of azotic and carbonic acid gas, in the proportion of 20 to 6, the whole of the oxygen being either absorbed, or converted into carbonic acid.

" *January 19th 1797.* A quantity of barley, previously steeped in water for 48 hours, was introduced, as in the last experiment, into a jar containing oxygen gas, and inverted over water, to which sulphuric acid had been added. At the end of 3 days it began to grow, and this process went on to the 29th. The water had now risen considerably in the jar, the gas having suffered a diminution of about one third. The barley being withdrawn, smelled completely like malt, and tasted sweet. The gas in the jar, on examination, was found to consist of 64 parts of carbonic acid, 32 azot, and 4 oxygen; from which it would appear that the air employed in this experiment had contained originally about 20 per cent. of azotic gas.

" To be more certain of the nature of the change which the pure air undergoes in this process, the experiment was repeated as follows.

" *January 23d.* A quantity of barley, soaked in water for 2 days, was introduced into a jar containing very pure oxygen gas, and inverted over mercury. At the end of 3 days the barley began to grow, and the process continued for 10 days, although very slowly; the column of gas remained exactly of the same height, so that it had undergone no apparent diminution or increase. The barley being withdrawn, the air in the jar was examined, and found to consist of carbonic acid gas, mixed with only 1-50th of its bulk of oxygen gas. The barley was partly converted into malt, the quantity of oxygen being insufficient to produce this change upon the whole.

" Another experiment with common air was made at the same time, and exactly under similar circumstances. In this case the barley did not begin to grow till the end of the 4th day; and at the end of 10 days, had made much less progress than that in the oxygen gas. It was now withdrawn, and the air in the jar, which had increased a little, examined, when it was found to consist of carbonic acid and azotic gas, in the proportion of 1 to 2 nearly, mixed with a very small quantity of oxygen gas; a little of the barley tasted sweet.

" Being now satisfied, that during the evolution of the saccharine principle from vegetable mucilage, &c. a quantity of oxygen was either absorbed, or converted into carbonic acid; we wished to know if this process could take place in any degree, without the presence of this gas.

" In order to determine this point, the following trials were made.

" *January 20th.* A quantity of barley, soaked as in former experiments, was

introduced into a jar filled with, and inverted over mercury. At the expiration of 12 days, a very considerable quantity of gas was produced, an least five or six times the bulk of the barley, but nothing like vegetation was perceivable; this, on examination, was found to be carbonic acid gas, being entirely absorbed by lime water. The barley had not the least sweet taste, nor did it appear to have undergone any sensible change.

" *On January 20th*, Another portion of the same soaked barley was introduced into a wine glass, and placed in a jar containing nitrous gas, inverted over water. At the expiration of 10 days, the gas had undergone a slight diminution, but there was not the smallest appearance of vegetation. The barley being withdrawn, and examined, was found to have undergone no apparent change. The gas contained about 1-9th of its bulk of carbonic acid, the remainder being pure nitrous gas, as was manifest from the diminution it underwent, when mixed with pure air. The nitrous gas which disappeared in this instance must have been absorbed either by the barley or the water; the carbonic acid gas which was found mixed with it, is accounted for by the last experiment:

" Two other portions of soaked barley were introduced into jars, the one containing hydrogenous, and the other azotic gas, and inverted over mercury. At the expiration of 12 or 14 days, there was not the least appearance of vegetation in either, but the gas in both had increased in bulk about 1-5th. The barley being withdrawn and examined, that in the hydrogenous gas tasted musty, but not in the least sweet; the portion in the azot appeared to have undergone no change. The gas in both jars contained from 1-3d to 1-4th of its bulk of carbonic acid, the remainder being the original gases not sensibly changed.

" From these experiments, therefore, it is manifest, that oxygen is absolutely necessary for the conversion of vegetable mucilage, and fecula, into sugar; as in no one instance was saccharine matter formed where this was not present, and the quantity of the former bore always a certain proportion to that of the latter; for we found in all the trials, that when the oxygen was consumed, this process immediately ceased.

" It may still remain doubtful, whether the oxygen is absorbed by the barley, or merely converted into carbonic acid. We are inclined to think, that it is chiefly absorbed, although part may also be consumed in the formation of this acid; for we have seen that carbonic acid is formed without the presence of oxygen gas, and that in very considerable quantity, which we conceive must proceed from the decomposition of the water, whose oxygen unites with the carbonaceous principle of the barley, whilst its hydrogen is fixed, and may be necessary to the production of the saccharine principle. We suppose, therefore, that vegetable mucilage is converted into sugar by being deprived of part of its carbon, whilst at the same time it unites with a greater proportion of oxygen, and probably also with hydrogen, from the decomposition of the water. Thus then, both from analysis and synthesis, it would appear, that sugar contains more oxygen than gum or mucilage. From this hypothesis it should follow, that if sugar were deprived of part of its oxygen, it must lose its sweetness, and form something like a gum. To see how far this might be accomplished, was the object of the following experiments.

A quantity of syrup was introduced into a jar filled with, and inverted over mercury; to this was admitted about an equal quantity of the phosphuret of lime; a considerable production of phosphoric gas almost immediately took place, and the mercury descended in the jar. At the expiration of eight days the syrup was withdrawn, and examined; it had no sensibly sweet taste, but rather a bitter

astringent one; when filtered, alcohol produced a copious white precipitate in flakes, very much resembling mucilage separated from water by the same substance.

The experiment was somewhat varied as follows: A little refined sugar was dissolved in alcohol, and to this solution a little phosphuret of lime was added; no phosphoric gas was disengaged, nor was there any apparent action produced. More phosphuret being added, the mixture was allowed to remain in an open phial for several days. The alcohol being now evaporated, some distilled water was added; but this produced no disengagement of gas, as the phosphuret had been decomposed, and converted principally into phosphat of lime. The mixture being filtered, and the clear liquor evaporated, there remained a substance extremely tenacious, and which had much the appearance of gum arabic; its taste was bitter, with a very slight degree of sweetness; when squeezed between the teeth it had exactly the feel of gum, but more tenacious. It did not appear to be soluble in alcohol, or at least in any considerable quantity; when thrown upon a red hot iron it burned like gum, and left a bulky and insipid charcoal.

It would appear that the saccharine principle had been destroyed in these experiments, and converted into something resembling a gum; that this was effected by the abstraction of oxygen is rendered highly probable, from the nature of the substance employed, and the change which it was found to have undergone; for there are few substances which have so strong a tendency to combine with oxygen as the phosphuret of lime.

"Some other trials of a similar nature were made, by mixing solutions of sugar with the different sulphurets, and by agitating them with nitrous gas in close vessels. The sulphurets, more especially that of potash, manifestly destroyed the saccharine taste; but on account of the solubility of the different products, the nature of the change could not be so easily and accurately ascertained. The action of the nitrous gas was more doubtful.

"In order to be satisfied how far the effects produced on the sugar in the former experiments might be owing to the abstraction of oxygen, we added to solutions of this substance in water, both lime and pure potash, and boiled the mixtures for some time. The lime manifestly combined with the sugar, to which it communicated a very bitter astringent taste, but it was still sweet; a little alcohol added to the filtered solution, produced a precipitate in white flakes, somewhat similar to that in the experiment with the phosphuret, and which appeared to be a combination of sugar with lime. Vitriolic acid likewise precipitated the lime in the form of selenite, and in a great measure restored the natural taste. Some of the filtered solution being evaporated by a gentle heat, there remained a semi-transparent substance, much more tenacious than the thickest syrup, but not equal to that produced by the phosphuret of lime, and it had a rough bitter taste, mixed with a certain degree of sweetness. The potash likewise appeared to combine with the sugar, the sweet taste being more completely destroyed than by the lime; but on the addition of sulphuric acid, sulphat of potash was formed, and this being precipitated by alcohol, the sweetness appeared to be completely restored. It may likewise be proper to observe, that when alcohol was added to a portion of the solution of sugar and pure potash, after it had been boiled to the consistence of a syrup, no union took place, but the alcohol, notwithstanding the mixture was completely and repeatedly agitated, still swam pure on the top; a circumstance which would seem to prove, that a new compound is formed by these substances, which is not soluble in this fluid, although they are both completely so in a separate state.

"Having found, that sugar might be converted into a species of gum, by de-

priving it of part of its oxygen, we conceived that gum might, by the addition of oxygen, be changed into a substance resembling sugar; but although several trials were made, with a view of combining oxygen, in different proportions, with gum arabic, no remarkably sweet taste was at any time perceived; on the contrary, in every experiment, it seemed to run very readily into the acid state, particularly when exposed to the action of the oxygenated muriatic acid gas.

"From the failure of these trials to convert mucilages into something resembling sugar, we began to suspect that they were not so simple as had been generally supposed. With a view to throw some light on this subject, the following comparative experiments were made.

"One ounce of powdered gum arabic was introduced into a coated glass retort, to which a receiver with a pneumatological apparatus was adapted; heat being gradually applied, there came over into the receiver 3 drachms 30 grains of pyromucous acid, mixed with a little heavy empyreumatic oil; after the retort had been red hot for some time, it was removed, and the charry residuum which it contained was found to weigh 1 drachm 46 grains. This had a greyish colour, and burned very slowly; but when exposed to a strong heat in an open crucible, it left a whitish powder, amounting to 10 grains, which was found to be lime mixed with a very small proportion of calcareous phosphat.

"The pyromucous acid being super-saturated with lime, a strong smell of ammonia was instantly perceived, and a piece of paper dipped in muriatic acid, being held over the vessel, copious white fumes were immediately produced. This circumstance shows, that azot forms a constituent part of the gum.

"There were collected in the pneumatological apparatus, 273 ounces measure of gas; of this 93 were carbonic acid, and the remaining 180 that species of hydro-carbonat, which is obtained by heat from moistened charcoal.

"Two measures of this gas, well freed from carbonic acid, were mixed with 1 1/2 of very pure oxygen gas, and introduced into a strong glass jar, filled with, and inverted over mercury; when fired by the electric spark, they occupied the space of one measure only; lime water being admitted, the whole was absorbed, except a very small particle, which was found, from the nitrous test, to be pure air. From a number of experiments we have found, that twelve measures of oxygen gas when united with carbon, produce 10 of carbonic acid gas. Hence it follows, that the quantity of oxygen gas necessary to the formation of carbonic acid gas must in this case have been 1.1 measures, or a little better; the remaining .4 must therefore have been consumed in the production of water, and would be sufficient to saturate .8 of hydrogen, equal in weight to .048 of a grain nearly.

"Now an ounce measure of carbonic acid gas weighs .864 of a grain, and this contains .24 of pure charcoal; hence the quantity of pure charcoal to hydrogen in this inflammable gas, must be as .24 to .048, or 5 to 1.

"But one measure of pure hydro-carbonat, such as may be obtained from the decomposition of camphor, by making its vapour pass through a red hot earthen tube, or from the distillation of animal substances, opium, &c. requires two of pure air to saturate it, and the quantity of carbonic acid amounts to 1.45. which makes the proportion of carbon to hydrogen, as 12 or 13 to 1; hence these gases differ materially, and ought not to be confounded; indeed the difference between them is manifest, from the manner in which they burn when mixed with common air, and brought into contact with an ignited body; pure hydro-carbonat burns slowly with a perfectly white flame, and never detonates; on the contrary, the compound inflammable gas just mentioned, burns rapidly with a reddish blue

flame, and more or less of a detonation. We thought it necessary to mention this circumstance, as much confusion might be produced by applying the same name, to substances considerably different. It is remarkable that ether decomposed by heat, affords pure hydro-carbonat, whilst alcohol yields the mixed species.

" But to return—an ounce of gum tragacanth was submitted, in a coated glass retort, to a similar process, and the products collected were as follows:

	Dr.	Gr.
Charcoal remaining in the retort	1	45
Pyromucous acid	4	5
Carbonic acid gas	78	oz. meas.
Hydro-carbonat	91	ditto

" The charcoal burned slowly with a peculiar phosphorescent flame, and left a white residuum of 12 grains, which was found to consist of lime mixed with a little calcareous phosphat.

" The pyromucous acid being super-saturated with lime, the quantity of ammonia disengaged appeared to be considerably greater, than from that afforded by the gum arabic.

" Having in this way discovered lime in both species of gum, we were anxious to know, if this earth could be detected by reagents, without having recourse to decomposition by heat. Accordingly a quantity of sulphuric acid was dropped into a solution of gum arabic: after standing for some hours, a number of needle-like crystals were slowly deposited; these being separated were redissolved in distilled water; to this solution the oxalat of ammonia was added, when a copious precipitate of oxalat of lime immediately took place.

" From these experiments therefore, it is manifest, that gums consist of oxygen, hydrogen, carbon, azot and lime, with a little phosphoric acid.

" An ounce of refined sugar was next introduced into a coated retort, and the pneumatological apparatus applied as in the former experiments. The products obtained were,

	Oz.	Dr.	Gr.
Pyromucous acid, with a drop or two of pyreumatic oil	0	4	30
Charcoal	0	2	0
Hydro-carbonat	119	oz. meas.	
Carbonic acid	41	oz. meas.	

" The pyromucous acid being super-saturated with lime, not the least vestige of ammonia could be perceived—sugar therefore does not contain azot; neither does it contain lime, for the charcoal, which was of a beautifully black colour, burned out completely, when exposed to a strong red heat.

" Being desirous of ascertaining more completely, the difference between common sugar, and the saccharine matter secreted by the breasts of animals, an ounce of the crystallized sugar of milk, was distilled in an apparatus similar to that already described, and the products were found to be

	Oz.	Dr.	Gr.
Pyromucous acid mixed with a very little empyreumatic oil	0	6	0
Charcoal with a little phosphat of lime	0	1	0
Carbonic acid gas	31	oz. meas.	
Hydro-carbonat of the same nature with that obtained in the former experiments	103	ditto.	

" The charcoal being burned in an open crucible, their remained about one grain, which appeared to be phosphat of lime chiefly.

" The pyromucous acid was next super-saturated with lime, but the quantity of ammonia difengaged was so small, that it could with difficulty be detected; there appeared however to be a very little.

" Hence then it would seem that this animal sugar, contrary to what might be expected, contains hardly any azot.

" It would appear also, that it contains less charcoal and more oxygen than common sugar.

" In order to investigate still further the nature of these substances, we endeavoured to ascertain the quantity of oxalic basis or radical, contained in each, or how much oxalic acid they would afford, when treated with an equal proportion of the nitrous acid.

" An ounce of sugar was added to six ounces of the concentrated nitrous acid, diluted with an equal bulk of water; when the action had in a great measure ceased, heat was applied, and the evaporation continued until the liquor was reduced to about an ounce by measure: after this had cooled, the crystals were separated by filtration, and the remaining fluid again evaporated, until the whole, when cold, shot into a mass of crystals, leaving only a few drops which refused to crystallize; these crystals being collected, and well dried on blotting paper, amounted to 4 drachms 20 grains, or a little better than half the weight of the sugar employed.

" An ounce of gum arabic was next treated with an equal proportion of nitrous acid properly diluted; the quantity of crystals collected amounted to 3 drachms 36 grains; but in this instance, the last crystals obtained were mixed with an insoluble white powder, which being separated from the oxalic acid, by the addition of distilled water, amounted to 6 grains, and was found to be oxalat of lime. The pure acid therefore did not exceed 3 drachms and a half. An equal quantity of gum tragacanth afforded by the same process 3 drachms 10 grains of oxalic acid, and 10 grains oxalat of lime.

" An ounce of the sugar of milk was also treated in a similar manner with 6 ounces of the concentrated nitrous acid properly diluted; and there were obtained in all 3 drachms 48 grains; these crystals, however, were mixed with a white powder, which being but little soluble in water, was readily separated; it amounted to 30 grains, and appeared to be the saccholarctic acid of Scheele; hence the pure oxalic acid did not exceed 3 drachms 18 grains.

" An ounce of honey yielded by a similar process 4 drachms 4 grains of pure oxalic acid, but exhibited no signs of saccholarctic acid.

" The following table will show at one view the different products resulting from destructive distillation, with their relative proportions; and likewise those obtained by the nitrous acid.

Substances employed, 1 oz. of each.	Products obtained by heat.				Products obtained by nitrous acid.	
	Charcoal, &c.	Pyromucous acid, &c.	Carbonic acid gas.	Hydrocarbonat.	Oxalic acid.	Other substances.
	Oz. Drs. Grs.	Oz. Drs. Grs.	Oz. measures.	Oz. measures.	Oz. Drs. Grs.	None.
Sugar - - -	0 2 0	0 4 30	41	119	0 4 20	None.
Honey - - -					0 4 4	None.
Sugar of milk	0 1 0	0 6 0	31	103	0 3 18	30 grains of saccholactic acid.
Gum arabic	0 1 36 and lime 10	0 3 30 with some ammonia.	93	180	0 3 30	Oxalat of lime 6 grains.
	0 1 46					
Gum tragacanth	0 1 33 and lime 12	0 4 5 with some ammonia.	78	91	0 3 10	Oxalat of lime 10 grains.
	0 1 45					

"From these experiments it would appear, that sugar consists merely of carbon, hydrogen, and oxygen, and that gum differs from sugar not only in containing a less proportion of oxygen, but also by its combination with lime and azot; and that the sugar of milk differs from both, as it contains the radical of the saccholactic acid; in other respects, however, it approaches very nearly to the nature of vegetable sugar. Does the milk of carnivorous and granivorous animals yield the same proportion of this acid, and is this sugar itself always of the same nature?

"From the well-known facts respecting vinous fermentation, there is now reason to suppose, that no substances, but those which consist simply of carbon, hydrogen, and oxygen, are susceptible of it, and that an union with a fourth, changes the nature of the compound so much, as to render this process impracticable.

" With a view to throw some light on this obscure subject, the following experiments were made.

" *August 4th*, 1798. An ounce of sugar, dissolved in 5 ounces of water, was digested with a little fresh slaked quicklime, in a moderate heat for about 15 minutes; the solution was then filtered, and about 2 drachms by measure of good yeast added; the vessel and mixture, weighing 17 oz. 2 dr. were introduced below a large bell glass.

" There was placed close to it, as a standard, another vessel, containing an ounce of sugar dissolved in 5 ounces of warm water, and to which an equal quantity of yeast was added. This vessel and mixture, which weighed together 17 ounces 1 drachm 20 grains, were likewise placed under a bell glass. The temperature of the room during the whole of this experiment was rather high, and varied from 68° to 75° of Fahrenheit.

" The last mixture began to ferment in 12 hours, and in 24 the process seemed very brisk, much water now condensing on the side of the bell. In five days the process began to subside; in seven the yeast fell to the bottom, and the liquor became clear. The mixture, at this time, smelled strongly of beer turned a little sour, although it still tasted sweetish. It was suffered to remain until the 28th, when it was removed from the bell and weighed, and the loss was found to exceed three drachms; it now tasted much like a mixture of strong vinegar and honey.

" During the whole of this period, amounting to 24 days, the mixture containing the sugar digested with the lime, never showed the least appearance of fermentation, nor was there any moisture condensed on the sides of the bell. The vessel and mixture being now weighed, the loss amounted to two drachms nearly; the liquor smelled very musty, and had a rough astringent taste mixed with sweetness, but was not in the least acid. In this instance the yeast fell to the bottom very soon, the liquor continued more or less muddy, and became, at last, a little mouldy at the top.

" We next digested an ounce of sugar, dissolved in five ounces of water with a little potash, and to the filtered solution added about two drachms of very good yeast. This mixture was exposed in an open vessel to a temperature of about 65°; and another vessel, containing a solution of an equal quantity of sugar, mixed with yeast, placed by it as a standard.

" The solution with the yeast alone, began to ferment in 12 hours; but the other containing the potash, showed no symptoms of fermentation at the end of 12 days.

" Being now in a great measure satisfied that any fourth substance combined, although in small quantity, with the three which form sugar, would prevent fermentation, we next wished to know if every compound, consisting of carbon, hydrogen, and oxygen, however differently these substances might be proportioned, were susceptible of this process. The sugar of milk, from what has been already observed, evidently consists of these three simple substances, but from a number of its sensible properties, and the result of its analysis by heat, as well as its containing the radical of the saccholactic acid, it is manifest that their combinations and proportions must be very different from those of common sugar.

" We therefore mixed a solution of this saccharine matter with the usual quantity of yeast, and exposed it to a temperature ranging from 65° to 70°; in four days some degree of fermentation was perceptible, and in three days more became brisk; at the end of sixteen, when this process had apparently ceased, the liquor was examined; it now had the smell of cyder, but rather more of the flavour of

apples; to the taste it was very sour, and when added to the tincture of litmus, strongly reddened it.

" The acid thus produced, either contained, or consisted of common vinegar; for, with the oxyd of lead, it formed a sweet saline mass, composed evidently of slender prismatic crystals, which were not deliquescent*.

" Hence it is manifest, that the sugar of milk is at least in some degree susceptible of the vinous fermentation.

" Having observed in our attempts to convert gum into sugar, that it seemed to run easily into the acid state, we were anxious to know if any thing like fermentation preceded this state, or if it was possible to convert it into an acid, by mere exposure to the air, without the addition of some substance containing much oxygen, as the nitrous or oxygenated muriatic acids. Accordingly a solution of gum arabic, mixed with a proper proportion of good yeast, was introduced into an open vessel, and kept at a temperature ranging from 68° to 75° for twenty-six days, but during this period nothing like fermentation was perceived—the mixture at last emitted a very peculiar and offensive smell, the gum, however, still retained its natural taste, and was not in the least sour. In this case it would appear, that the azot and lime, which in the gum are combined with carbon, hydrogen and oxygen, prevented the vinous fermentation, and consequently the formation of any thing like vinegar.

" It has been supposed, that a decoction of purely animal matter might undergo certain spontaneous changes, and at last become acid. In order to determine this point, about sixteen ounces of a strong decoction of beef were introduced into an open vessel, and kept at the temperature of about 68° or 70° . A few days after, an equal quantity of a similar decoction, mixed with an ounce of yeast, was likewise exposed in an open vessel, to air of the same temperature.

" At the end of five days, the decoction, without any mixture, began to show evident marks of putrefaction, but did not in the least taste acid, nor had it ever shown any signs of vinous fermentation; in two days more it became extremely offensive, accompanied with the production of ammonia.

" The decoction with the yeast did not show any evident signs of putrefaction until the seventh day, but there was nothing like fermentation perceived; in two days more, it became extremely putrid and offensive, and was thrown away.

" Hence it would appear, that neither vegetable nor animal mucilages are, when pure, in any degree susceptible of the vinous fermentation; indeed these are facts, which have been so generally admitted, that had not a contrary opinion been lately advanced, we should have conceived the three last experiments unnecessary.

" The mistake has no doubt arisen from observing the facility with which a decoction of a mixture of animal and vegetable matter, runs into the acid state; but in this case, the animal substance performs the part of yeast only; and it is in this way that diabetic urine so readily ferments spontaneously, and becomes vinegar.

" From the preceding experiments, we may draw the following conclusions:

" 1st, That sugar consists of carbon, hydrogen, and oxygen; and may be considered as a pure vegetable oxyd.

" 2d, That sugar of milk is composed of the same principles, but contains more oxygen, and considerably less charcoal.

" 3d, That gum differs from sugar in containing, besides carbon, hydrogen and oxygen, both lime and azot.

* See Scheele's Essays, page 274.

" 4th, That vegetable farina cannot be converted into saccharine matter, without the joint action of oxygen and water, the first of which appears to be absorbed, and the last decomposed during this process.

" 5th, That when sugar is deprived of its oxygen, or combined with other substances, it loses its characteristic properties, and is no longer susceptible of the vinous fermentation.

" 6th, That neither vegetable nor animal mucilages, in their pure state, are susceptible of this process."

CHAPTER IX.

OF FIXED OR EXPRESSED OILS.

OILS are proper juices, of a fat and unctuous nature, either solid or fluid, indissoluble in water, combustible with flame, and volatile in different degrees; they are contained in the proper vessels, or in peculiar vesicles. These substances are found in two states in vegetables; either combined with other principles, as in extracts, mucilages, &c. or at liberty. Our attention must at present be directed to the latter.

Chemists have supposed the existence of a simple oily principle, as well as of a primitive salt. This oily principle, combined with different substances, and modified by these combinations, constituted, according to them, the different species of oils obtained in the analysis of vegetables. The characters attributed to this simple and primitive oil, were great fluidity and volatility, neither colour nor smell, combustibility with flame and smoke: it was said to be incapable of uniting with water, and to consist of water and an acid combined with an earth and phlogiston. It is certain that oils, in their decomposition, always afford a small quantity of acid, and much hydrogen gas: the earth forms but a small part, as they leave but an inconsiderable quantity of fixed and coaly residue. This notion, respecting the oily principle, must be considered as a mere hypothesis.

Oils are never formed but by organic bodies; and all substances in the mineral kingdom, which present oily characters, have originated from the action of vegetable or animal life. It is even very probable that they are only formed in vegetables, and that they pass without alteration into animal substances.

The oily juices of vegetables are distinguished into fixed oils and volatile oils.

Fixed oils, named likewise fat oils, sweet oils, expressed oils, are very unctuous; their taste is commonly mild and insipid, and they have no smell; they are not volatilized but by a heat su-

perior to that of boiling water, and do not take fire till heated sufficiently to volatilize them. The wick, which is used to burn fat oil in lumps, answers this purpose; it heats the oil to such a degree, as volatilizes it.

Most fixed oils are fluid, and require a considerable degree of cold to congeal them; others become solid by a very slight degree of cold; and others again are almost always solid: these last are called *vegetable butters*, though very improperly.

Fixed oils are not emitted from the surface of vegetables, but are contained in the kernels, the pippins, and emulsive seeds. They are extracted by breaking the cellules by which they are enclosed; that is to say, by pounding and pressure.

Fixed oils exposed to air are changed, and become rancid; their acid becomes developed, and they lose their properties, at the same time acquiring others, by which they more nearly resemble volatile oils. Water and alcohol, by washing off this disengaged acid, deprive them of their strong taste, but never restore their original state ^a.

Berthollet has discovered, that fat oils thinly spread on the surface of water, and exposed to the air, become thick, and resemble wax. It is now demonstrated, that this thickening arises from the absorption of atmospheric oxygen, because all the substances which contain this principle, and which yield it to the fixed oils, as several acids, and particularly the oxygenated muriatic acid with metallic oxyds, thicken the fixed oils, and reduce them to the state of wax.

By distillation they afford an acid phlegm of a penetrating smell, a light oil, a denser oil, and a large quantity of hydrogen gas mixed with carbonic acid. The quantity of residual coal is not abundant. By redistilling these, sebacic acid, of which we shall treat in the animal kingdom, and an oil which becomes lighter each time, are obtained. This is known by the name of *philosophical oil*; the alchemists prepared it by distilling, for several successive times, a fixed oil with which they had impregnated a brick. It is not exactly known how far this decomposition may be carried, though it is said that fixed oil may this way be reduced into the disengaged inflammable principle, water, acid, air, and earth ^b.

Water does not produce any change in fat oils in the cold,

but it purifies them, by carrying off part of their mucilage, which is likewise precipitated during their combustion, and is the cause of their property of fermenting and becoming rancid. It is well known, that water thrown on burning oils, causes them to give a stronger flame, instead of extinguishing them. This depends on the decomposition of the water, which affords oxygen to the oils, and allows much hydrogen gas to escape. When the vapour of the flame of burning fat oil is collected in a chimney, terminated by a worm pipe, a large quantity of water is obtained; whence it follows, that this immediate principle of vegetables contains hydrogen.

Fixed oils do not combine with siliceous earth: with clay they form a soft paste used in chemistry, by the name of *fat lute*.

By particular processes they combine with magnesia, which reduces them to a saponaceous state.

Lime unites with oils, but not in a very evident manner when the substances are immediately applied to each other.

Pure alkalis combine readily with fat oils, and produce a compound called *soap*.

To prepare this compound, oil of olives, or of sweet almonds, is triturated with a concentrated lixivium of soda, rendered caustic by lime, and known by the name of *soap lye*. The mixture becomes thick in a few days, and is converted into the soap used in medicine. The soap of commerce is made by boiling the lixivium with rancid oil; it is then white. Green soap is made with the marc of olives and potash.

Soap is soluble in pure water; heat decomposes it, and disengages phlegm, oil, and ammoniac produced from the fixed alkali and the oil; the coal contains much fixed alkali. This artificial composition of ammoniac seems to prove, that fixed alkalis contain azot, which reacts on the hydrogen of the oil.

Lime water decomposes soap, according to the observation of Thouvenel; an insoluble calcareous soap is then formed, which is deposited in grains. Acids poured on soap disengage the oil, but somewhat altered.

The ammoniac does not combine with fixed oils without difficulty; yet, by long trituration, the mixture becomes opaque, and rather more consistent.

Fixed oils unite with acids, and form peculiar soaps, when the acid made use of is weak. Achard, Cornette, and Macquer, have made experiments respecting these compounds. Achard added concentrated sulphuric acid, by small portions, to fixed oil. This mixture being continually triturated, becomes at length converted into a brown mass, soluble in water and alcohol. The oil obtained from this soap by alkalis, as well as by distillation, is always more or less concrete. Macquer advises, in making this soap, to pour the acid on the oil; but he observes, that an acid soap made in this manner is scarcely soluble in water. The soap which is prepared by triturating common alkaline soap with concentrated sulphuric acid, is more soluble. The concentrated sulphuric acid renders fixed oils black, and causes them to resemble bitumens. This phenomenon appears to arise from the reaction of the hydrogen of the oil on the oxygen of this acid.

The fuming nitrous acid immediately changes fixed oils to a black colour, and inflames such as are of a drying nature. Those which do not dry cannot be inflamed, but by a mixture of this acid, and that of sulphur, as Rouelle the elder has shown in his *Memoirs on the Inflammation of Oils*, printed among those of the Academy for the year 1747.

The muriatic and carbonic acids act but weakly on fixed oils; the former, however, in a concentrated state, combines with them to a certain degree, according to Cornette. The oxygenated muriatic acid thickens them much, and appears, by the absorption of its oxygen, to convert them into a substance nearly resembling wax.

The action of the other acids on fixed oils is not known; these oils do not appear to combine with neutral salts. Many of the latter, more especially the calcareous salts, decompose alkaline soaps. In this decomposition, especially that effected by the sulphates of lime and magnesia, which are frequently contained in water, the sulphuric acid unites with the fixed alkali of the soap, and forms sulphate of soda; the lime or the magnesia combines with the oil, and forms a kind of soap scarcely at all soluble, which floats in whitish curd-like masses on the surface of the water. This is the cause of the common appearance produced by hard waters, when attempts are made to use them with soap.

The action of hydrogen gas on fixed oils has not yet been examined.

Fixed oils dissolve sulphur in a boiling heat, and this solution is of a deep brownish red colour, of a very fetid smell, and gradually deposits sulphur in the crystalline form. When this combination is distilled, the sulphur is volatilized, dissolved in the disengaged hydrogen gas of the oil, and cannot be found again in the solid state. This experiment well deserves to be carefully repeated. Sulphureous gas is likewise obtained in this decomposition.

Fixed oils do not appear capable of uniting with pure metallic substances, excepting copper and iron, on which they have a considerable action. But they combine with metallic oxyds, and form thick, concrete combinations, of a soapy appearance, as may be observed in the preparation of unguents and plasters. These preparations have not yet been chemically examined; it is only known, that certain metallic oxyds are reduced in the formation of plasters; as for example, the oxyds of copper and lead, &c. In domestic operations, fixed oils are used to reduce metallic oxyds. Berthollet describes an ingenious and simple process, for immediately combining a fixed oil with any metallic oxyd, in the saponaceous form. It consists in pouring a solution of soap into a metallic solution; the acid of the latter seizes the fixed alkali of the soap, and the metallic oxyd is precipitated in combination with the oil, to which it communicates its colour. In this manner a beautiful green soap is formed with sulphat of copper, and a brown soap with sulphat of iron; these compounds may perhaps be useful in painting. Scheele has discovered, that by combining oil of sweet almonds, of olives, of rape, or of linseed, with the oxyds of lead, and adding a small quantity of water to the mixture, a substance is separated, which he calls the sweet principle. By evaporating the water, this principle is obtained, of the consistence of syrup; by a strong heat it takes fire; part is volatilized in the distillation without burning; the residual coal is very light. The sweet principle does not crystallize, nor does it appear susceptible of fermentation; nitric acid distilled four times from it produces oxalic acid. This principle appears to be a kind of mucilage.

Fixed oils dissolve bitumens, and, in particular, amber, but they require the assistance of heat. These combinations are a kind of fat varnish, which does not become dry without difficulty.

Fat oils may be distinguished into three genera.

The first comprehends pure fat oils, which congeal by cold, thicken slowly, form soaps with acids, and do not take fire by the nitric acid, unless sulphuric acid be likewise used.

1. Such are oil of olives obtained from the pulp of that fruit, crushed between two mill-stones, and pressed in sacks made of rushes. The first product is called *virgin oil*; that which is obtained from the marc, moistened with water, is less pure, and deposits a sediment. The oil of unripe olives is the *oleum omphacine* of the ancients. Oil of olives freezes at ten degrees above zero, on Reaumur's thermometer, and does not become rancid in less than about twelve years.

2. Oil of sweet almonds extracted without heat, becomes quickly rancid; it does not freeze till its temperature is reduced to six degrees above 0 of Reaumur's scale.

3. Oil of rape obtained from the seeds of a kind of cabbage called *colza*.

4. Oil of ben, extracted from the ben nut, from Egypt and Arabia; it is very acrid, inodorous, and freezes very easily.

The second genus comprehends drying oils, which soon become thick, do not congeal with cold, are inflamed by the nitric acid alone, and form a kind of resin with sulphuric acid.

1. Such are linseed oil, obtained by pressure from linseed. It is used in oily varnishes, and in painting.

2. Nut oil applied to the same use.

3. Oil of poppy seeds, which is not at all narcotic, as the Abbé Rozier has clearly shown.

4. Oil of hemp seed, which is very drying.

In the third genus we comprehend concrete fat oils, or *vegetable butters*, among which we may distinguish the following.

1. Butter of cocoa, obtained from the chocolate nut: four species of cocoa are distinguished; the large and small caracca, the berbice, and that of the islands. The butter is extracted

by ebullition in water, and is purified by melting with a gentle heat.

2. The cocoa nut affords a butter of the same kind.

3. The wax of vegetables is of the same kind, excepting that it is more solid. It is extracted from the *gale* in China, where it is made into yellow, green, or white candles, according to the manner in which the wax is extracted. The catkins of birch and poplar afford a small quantity of this kind of wax. That of Louisiana is more abundant; Berthollet quickly bleaches it with the oxygenated muriatic acid.

The use of fixed oils in the arts, and in medicine, is very extensive. They are medically prescribed as relaxing, softening, and laxative remedies; some are even purgative, as the oil of Ricinus, or Palma Christi, which has been likewise discovered to possess the property of destroying and evacuating the tenia, or solitary worm. They enter into many medical compounds, such as balsams, unguents, plasters, &c.; they are often used as food, on account of the mucilage they contain.

NOTES ON CHAPTER IX.

FIXED OILS.

^a SENNEBIER remarks, that oils which are exposed to the contact of air, absorb this substance, become white, and lose their fluidity, and in time become rancid and glaring. Though these changes take place in the dark, yet they are greatly promoted by exposure to light. They take place also much sooner in oxygen gas, than in common atmospherical air. *An. de Chem.* Tom. XI. p. 89.

^b Oils which are imperfectly burned deposit a foot, to which we give the name of *lamp-black*. This substance seems to be merely the unchanged carbon of the oil; for when every part of the oil in combustion is exposed to the action of the air, as in *Argand's lamp*, no foot whatever is formed. The products in this case are merely water and carbonic acid gas. 100 pounds of olive oil, according to Lavoisier, consist of,

	Lbs.	Oz.	Gros.	Grains.
Carbon,	78	15	2	68
Hydrogen,	21	9	5	4

Mém. de le Acad. 1784.

From the fixed oils becoming rancid by keeping, and from their affording an acid phlegm, as well as a small portion of carbonic acid, by distillation, there is

reason to believe they contain a portion of oxygen, which has been overlooked by Lavoisier in his Calculation. *Putius. Crell's Ann.* 1785, B. II. p. 349."

c There is a memoir by Darcet, Lefevre and Pelletier, inserted in the 19th volume of the *Annales de Chemie*, which contains much new, accurate, and interesting information respecting the preparation of the different kinds of soap. This memoir, which, from the nature of the subject, does not easily admit of abridgment, may be regarded as a complete treatise on the art of soap-making.

Chaptal proposes to form a new kind of soap, by dissolving, with the assistance of heat, wool in a solution of potash or soda. When these substances are employed by themselves, they are apt to injure the clothes, by dissolving a part of them, and by giving to them a disagreeable roughness.

The quantity of wool which alkali can dissolve, will depend on the strength of the ley, its degree of causticity, and the degree of heat employed. 2 pounds 3 ounces 6 gros of caustic alkali, at 12° of concentration, dissolved, in a boiling heat, 10 ounces 4 gros of wool. The soap, when cold, weighed 1 pound 4 ounces.

The alkali to be used in this process is to be prepared in the usual manner with quicklime. If the wool be not white, the soap will give a coloured tinge to the clothes which are washed with it. Wool soap seems to be best fitted for stuffs which are coloured, or are to be dyed. The animal odour which it gives to these stuffs goes off in the air.

Chaptal found, that this soap answered very well for cotton. It seemed to have the best effects in rendering cotton fit for the reception of colouring matter. He proposes to employ this soap in the domestic purposes of washing linen and wool, *An. de Chem.* Tom. XXI. p. 27.

CHAPTER X.

CONCERNING VOLATILE OILS.

VOLATILE or essential oils differ from fixed oils, by the following characters: Their smell is strong and aromatic: Their volatility is such, that they rise with the heat of boiling water; and their taste is very acrid. They are likewise much more combustible than the fixed oils. These oils exist in most strong smelling plants. They are either contained in the whole plant, as in the Bohemian angelica, or in the root only, as in star-wort, the iris, the white dittany, and the kidney-wort, &c. or in the stem, as in the woods of sandal, saffrafras, pine, &c. or in the bark, as in cinnamon. In some, the leaves only contain it, as is observed in balm, peppermint, wormwood, &c. in other plants it is found in the calices of the flowers, as in the rose, and lavender. The petals of camomile and orange flower abound with it. In others again, it is contained in the fruits, as in cubebs, pepper, juniper berries, &c. Lastly, Many vegetables contain this oil in their seeds, as nutmeg, anise, fennel, and most umbelliferous plants. Volatile oils differ from each other, 1. In the quantity, which greatly varies according to the state or age of the plant. 2. In consistence: some are very fluid, such as those of lavender, rue, &c.; others congeal by cold, as the oils of anniseed or fennel; others again are always concrete, as those of roses, parsley, kidney-wort, and star-wort. 3. With respect to colour: some are colourless, others yellow, as that of lavender; others deep yellow, as that of cinnamon; others blue, as that of camomile; others sea-green, as that of St. John's-wort; or green, as that of parsley. 4. By their weight: some float on water, as most of the oils extracted from plants growing in temperate countries; others, as those of saffrafras and carraway seeds, and most oils from hot countries, sink to the bottom. This property is not, however, constant with respect to climates, the essential oils of nutmeg, pepper, and mace, being lighter than water. 5. With respect to smell and taste: this last property is often very different in the vola-

tile oil from that of the plant. For example, pepper affords a mild oil, and the oil of wormwood is not bitter.

Essential oils are obtained, 1. By pressure, from the cedra, from bergamot, from lemons, oranges, &c.; this is termed *essence*. 2. By distillation: For this purpose, the plant is put into a copper alembic, together with water; the water being made to boil, comes over together with the oil into the receiver, and is obtained separate by decantation.

Volatile oils are adulterated either by the addition of fixed oils, which may be known by the stain such oils make on paper; or by oil of turpentine, which may be distinguished by its strong smell, that remains after the essential oil is evaporated; or by alcohol; then the water, by rendering the mixture, turbid, discovers the nature of this alteration.

Volatile oils lose their smell by a gentle heat; as they are very volatile, fire alone does not decompose them. When heated in close vessels, a large quantity of hydrogen is disengaged. When heated with contact of air, they quickly take fire, and emit a very thick fume, which becomes condensed into a fine and light coal matter: they leave very little fixed coal after their inflammation; because they are so volatile, that the coal matter is formed in the part which is volatilized.

By exposure to the air they become thick, and in process of time assume the character of resin. Needle-formed crystals are deposited similar to those afforded by camphire when sublimed. Geoffroy the younger, observed them in the essential oils of mother-wort, marjoram, and of turpentine. The same chemist observes, that their smell is similar to that of camphor*.

They unite difficultly with lime and alkalis, with which they form imperfect soaps, which we call *savonules*, and are changed by acids. The concentrated sulphuric acid converts them into bitumens; but if it be weak, it forms a kind of soap. The nitric acid causes them to burst into flame; the muriatic acid renders them saponaceous; and the oxygenated muriatic acid thickens them.

They have no action on neutral salts.

They combine very readily with sulphur, and form com-

* See the Memoirs of the Academy for the year 1727, p. 193.

pounds, called *balsams of sulphur*, in which the sulphur is so greatly divided that it can no longer be extracted, and is separated by heat, in the form of sulphurated hydrogen gas.

Mucilages and sugar render them soluble in water.

They are used as cordial, stimulant, antispasmodic, &c. remedies. Externally applied, they are powerfully antiseptic, and stop the progress of caries in the bones.

NOTES ON CHAPTER X.

VOLATILE OILS.

PROUST seems to have been among the first who examined accurately the crystalline ramifications which sometimes form in essential oils. By evaporating these oils in the open air, at a temperature varying from -6° to $+10^{\circ}$ of Reaumur, he obtained crystals, which he conceived to be camphor.

In every essential oil, according to Proust, there are two substances which have a tendency to combine with oxygen; one, the radical of a resin, the other the radical of an acid. The resinous radical seems to have the strongest affinity. The acid base operates only through a long period of time. These oils cannot be often exposed to the air, nor distilled repeatedly, without exhibiting some mark of acidity. Proust attributes the conversion of these substances into resins to the absorption of atmospherical oxygen. *An. de Chem.* Tom. IV. p. 179.

Margueron remarks, that some of the volatile oils assume the concrete state in a temperature about 8° above the freezing point of water; while others, again, retain their fluidity far below that point. This chemist observed carefully the phenomena which takes place, by exposing these oils in small flasks to a temperature of 11° below freezing. In the upper and internal part of the flasks, ramifications were to be perceived, similar to those which are formed on the glass panes of windows during an intense frost. The oil of Bergamotte, during its exposure to this cold, exhibited in its substance a quantity of small elliptic laminæ; that of citrons had deposited small crystals; the oil of oranges was the least fluid; and that of canella alba was partly congealed. By exposing these oils for two hours to an artificial cold of -22° , some of the corks were driven out of the flasks by the formation and sudden expansion of an elastic fluid, and the upper part of the flasks were at the same time covered with numerous saline, crystallized, dendritual ramifications.

The inferior surface of the flask, containing the volatile oil of peppermint, was covered with small needles, which were white, and melted readily between the fingers. Applied to the tongue, they produced the fresh and penetrating taste of the oil. Their solution in alcohol became white by the addition of water. The oil in the flask had acquired a kind of sluggish fluidity; its smell was less lively,

and its colour deeper than formerly. It was soluble in alcohol, and had lost a portion of its weight.

Ramifications were formed in the upper part of the flask, containing the oil of oranges. In uncorking the flask, a portion of an elastic fluid escaped; and this oil exhibited the same appearances with that of peppermint, except that it was more deeply coloured, and had lost its fluidity so as to adhere to the flask like oil of turpentine. Some particles were separated from it by mixing it with water, which remained constantly at the bottom of this fluid. Exposure to the artificial cold produced no other effect except giving rise to some crystalline laminæ, of an elliptic form. At 4° below zero it resumed its fluidity.

Volatile oil of lemons lost its fluidity by exposure to cold, at the same time that an amber coloured liquor and several small crystals were separated from it. The colour and taste of the oil had become less lively. The amber coloured liquor had an empyreumatic smell, a bitter and slightly acid taste; it was miscible with water, reddened tincture of turnsole, and did not precipitate lime water; but it effervesced with carbonat of potash. This liquor was in the proportion of 1-10th of the oil. The crystals had no very regular shape; they were insoluble in cold, but melted in warm water, and formed a pellicle on its surface during refrigeration. They melted by heat, and crystallized again in the form of small needles by cooling; they did not burn in the flame of a candle. Dissolved in alcohol, they gave a red tinge to tincture of turnsole.

The upper part of the flask containing the volatile oil of turpentine, was covered with a slight efflorescence; concretions of a white colour, and of a consistence greater than that of the oil, adhered to the sides of the flask. These concretions resumed their fluidity at 7° below freezing. The oil from which they were separated did not appear to have undergone any change.

A small portion of the oil of lavender, was volatilized by exposure to cold, and formed a kind of congelation at the upper part of the flask. The oil itself was deprived of fluidity, and had acquired a more intense colour.

The volatile oil of canella lost its fluidity by exposure to the cold, and exhibited a kind of crystallization. It resumed its fluidity at 4° below zero, without appearing to have undergone any change.

Margueron varied these experiments, by putting some distilled water into the flask containing the oils, and subjected the mixtures to the temperature of 11° below freezing. During the moment the water passed to the state of ice, several of the corks were forced out, and an aromatic principle disengaged. The flask containing the oil of peppermint was covered with a kind of capillary vegetation; the other oils exhibited nothing worthy of being remarked. The action of the cold on the oil of peppermint, had heightened the colour of the oil, and had weakened its smell; the crystalline needles separated from it were of a white colour, silky and brittle. They had the smell of peppermint applied to the tongue. They had a fresh and penetrating taste. They did not take fire with the flame of a candle, but melted and assumed by cooling, transparency and a solid form. The solution of these crystals in water, gave a red tinge to tincture of turnsole. The transparency of the alcoholic solution was not disturbed by the addition of water.

From these experiments, Margueron concludes, that cold disengages from volatile oils a part of their aroma, heightens their colours, renders them of a thicker consistence, and separates from them concretions some of which appear to be of a saline nature.

A saline concretion was obtained from the volatile oil of fennel, which melted in

the flame of a candle without being inflamed. It was insoluble in nitric acid. It dissolved in alcohol, and the solution gave a red tinge to tincture of turnsole.

Oil of wormwood kept for several years, had deposited a yellowish substance, which had the smell of the oil, and adhered to the fingers like turpentine. This substance inflamed in the candle, and left behind it a large carbonaceous residue. Heated in a capsule it became fluid, and some small needles were formed in it by cooling. The water on which this oil had been kept, reddened tincture of turnsole.

Volatile oil of sage, deposited by long standing a whitish, lamellated, crystalline concretion, which afforded some small needles by spontaneous evaporation. This concretion did not inflame in the candle; it acquired the consistence of turpentine in nitric acid.

These concretions which were formed in volatile oils, seemed to approach to the nature of resins, and to contain an acid salt similar in its properties to the flowers of benzoin, *An. de Chem. Tom. XXI. p. 174.*

Deyeux and Vauquelin, had discovered the properties of the benzoin acid, in the concretions deposited in the water of canella, so early as the year 1792.

CHAPTER XI.

CONCERNING THE CAMPHORATE PRINCIPLE.

CAMPBOR is a white concrete crystalline matter, of a strong smell and taste, which resembles volatile oils in some of its properties, and differs from them in others.

From a number of observations, chemists consider camphor as an immediate principle of vegetables, existing in all very odoriferous plants, that contain volatile oil. It has been obtained from the roots of zedoary, thyme, rosemary, sage, and other labiated plants, either by distillation or decoction, as Cartheuser and Newman have observed; but this camphor is in small quantities, and always has the smell of the plant from which it is obtained. This singular substance seems to be combined with the volatile oils of vegetables, as we may conclude from the observation of Geoffroy, mentioned in the foregoing chapter. M. Joffe, apothecary at Paris, showed me a true camphor obtained from the roots of star-wort. Lorry considered camphor as a principle abounding in vegetables, and placed its aroma at the head of a class of very powerful smells, whose effects on the animal economy deserve the attention of chemists and physicians. Proust has published a dissertation, in which he describes a process for obtaining a large quantity of camphor, from the oils of several aromatic plants which grow in Murcia.

The camphor used in medicine, is obtained from a species of laurel which grows in China, Japan, and in the islands of Borneo, Sumatra, Ceylon, &c. The tree which produces it, sometimes contains so large a quantity that it need only be cleft, in order to obtain very pure tears of camphor, of considerable size. It is obtained by distillation. The roots, or other parts of the tree, are put into an alembic with water, which is covered with a capital, containing ropes of rice straw. On the application of a sufficient heat, the camphor is sublimed in small grayish grains, which are afterwards united into larger masses. This crude camphor is impure; the Dutch purify it by sublimation, after previously adding an ounce of lime to each pound of the camphor.

Camphor is much more volatile than essential oils, and sublimes with the most gentle heat; it crystallizes in hexagonal laminæ, attached to a middle stem. By a sudden heat it melts before it rises. It does not seem decomposable by this means; yet if it be repeatedly distilled, it affords a reddish, and manifestly acid phlegm, which seems to show that the whole might be decomposed by repeating the operation a sufficient number of times. The temperature of the air in summer volatilizes it, so that it is entirely dissipated. In a close vessel it sublimes in hexagonal pyramids, or polygonal crystals, which were observed and described in the year 1756, by Romieu. Its smell is strong and insupportable to some persons; it takes fire readily, burns rapidly with much smoke, and leaves no carbonaceous residue.

It does not dissolve in water, to which, nevertheless, it communicates its smell: it burns on the surface of water. Romieu has observed, that small pieces of camphor, of the third or fourth part of a line in diameter, on the surface of a glass of pure water, have a rotatory motion, and are dissolved in the space of half an hour. He suspects that this motion is produced by electricity, and observes that it ceases when the water is touched with a body that conducts electricity, such as an iron wire; and that on the contrary, it continues, though the water be touched with an insulating substance, such as glass, resin, sulphur, &c.^a

Earths, the salino-terrestrial substances, and alkalis, have no action on camphor. It must, however, be observed, that experiments have not yet been made with the caustic alkalis.

Concentrated acids dissolve camphor. Sulphuric acid, assisted by heat, dissolves it, and becomes red. The nitric acid dissolves it without any intestine motion, and forms a yellow liquid, which, because it floats on the acid, has been called improperly *oil of camphor*. Mr. Rosegarten has discovered, as we have already observed in Chapter VII. that the nitric acid, by distilling it eight times successively from camphor, converts it into a crystallizable acid of a peculiar nature.

The muriatic acid, in the state of gas, dissolves camphor; as do likewise the sulphureous and fluoric acid gases. If water be added to these solutions, they become turbid, and the cam-

phor is separated in flocks, which float on the surface of the liquid, and does not appear to have sustained any change in its properties. Alkalis, and also the salino-terrestrial substances, and metallic matters, likewise separate camphor from acids.

Neutral salts have no action on camphor. The action of sulphur and bitumens on this substance is not known, though it is probable they would unite with it.

Fixed oils, and volatile oils, dissolve camphor by the assistance of heat. These solutions, by cooling, gradually deposit crystals in a vegetation similar to that which is formed in solutions of ammoniacal muriat; namely, a middle stem, in which very fine horizontal threads are inserted. This kind of feathers, examined by the magnifier, is very beautiful and regular. Romieu was the first who observed this beautiful crystallization (*Memoirs of the Academy* for 1756, page 448). The solution of camphor in alcohol, which is much better known and more used than the foregoing, presented this observer with a crystallization somewhat different, which he obtained by a peculiar process.

Camphor is one of the most powerful remedies the art of medicine possesses. It dissipates inflammatory tumors in a short time, by external application. It is used as an antispasmodic, and as an antiseptic remedy in contagious disorders, putrid fevers, and in general, in all disorders which are attended with nervous affections, or putridity. It is not administered in France in larger doses than a few grains; in Germany, and in England, it is given in the quantity of several drachms per day. It is of importance to be known, that camphor often mitigates heat and pain in the urinary passages, as it were by enchantment. It is given, triturated with yolk of eggs, sugar, gums, or in the state of oil of camphor; and is sometimes used in the composition of diet drinks. Surgeons use camphorated spirit of wine, whose composition we shall hereafter describe, in external gangrenes, and often with good success.

NOTE ON CHAPTER XI.

^a CAMPHORATE principle. Some curious phenomena of this kind are described by Prevost and Venturi, in memoirs to be found in the 21st volume of the *Annales de Chimie*.

CHAPTER XII.

CONCERNING THE AROMA, OR SPIRITUS RECTOR.

BOERHAAVE gave the name of *spiritus rector* to the principle in which the smell of plants resides. The properties of this singular substance, so interesting on account of its effects on the animal economy, are yet but little known. Instead of *spiritus rector*, we substitute the word *aroma*, from which the word *aromatic*, already so well known in our language, is derived.

The aromatic principle appears to be exceedingly volatile, fugacious, and attenuating. It is continually disengaged from plants, and forms an odoriferous atmosphere around them, to a greater or less distance. All plants differ from each other in the quantity, efficacy, and nature of this principle. Some contain it in great abundance, and are only in part deprived of it by drying, so that in these it appears to possess a certain degree of fixity. Such, in general, are the odoriferous woods, and all the dry and ligneous parts of strong-smelling vegetables. In others, this principle is so volatile and transient, that though they have much smell, the aroma can scarcely be retained, even with the greatest difficulty. Of this kind are the tuberose, jessamine, heliotrope, reseda, &c. Lastly, There are plants, which have a smell scarcely sensible; these are called *inodorous*, and their aroma has been distinguished by the appellation *herbaceous*.

The slightest heat is sufficient to disengage the aroma of plants. To obtain this principle, the plant must be distilled in a water-bath, and the vapours received in a head, which being kept cool, may condense them, and cause them to pass into the receiver in a liquid form. This product is a limped water, charged with the principle of smell, and is called the essential, or distilled water of the plant. This liquor must be considered as a solution of the odorous principle in water. The odorous principle is more volatile than the fluid which holds it in solution. Heat drives off the aroma and the liquid becomes, of course, deprived of its peculiar smell; exposure to air produces the same effect, very light mucilaginous flocks being de-

posited, and the smell of the fluid being changed to that of mouldiness.

The principle of smell unites with the oily juices, and even seems to be one of the component parts of essential oils; for,

1. They always abound with it.
2. Plants which have a permanent smell, constantly afford more essential oil than those whose principle of smell is very volatile, and which often afford no essential oil, as is the case with liliaceous plants. To retain the aroma of these last, as the lily, the jessamine, the tuberose, it is necessary to combine them with fixed oil. These flowers are placed in a cucurbit of tin, together with cotton soaked in the oil of ben: the flowers and the cotton are disposed stratum super stratum; and the cucurbit being closed, a gentle heat is applied. The aroma is disengaged, and combining with the oil, becomes durably fixed.
3. Plants which have no smell, do not afford the smallest quantity of volatile oil.
4. Vegetables, whose aroma has been extracted by distillation in the water-bath, no longer afford essential oil, or at least they do not, unless the distillation has been so managed, that they still retain part of their smell; in this case, they may afford a very small quantity.
5. A volatile oil, which has lost its smell, resumes it very readily, with all its properties, when re-distilled from a fresh plant, of the same kind as that from which it was originally extracted.

The action of saline substances on the aroma has not yet been examined. Berthollet has found, that the oxygenated muriatic acid often destroys the smell of vegetables, and consequently alters their aroma. It has of late been used to ascertain the strength or intensity of the aroma, of several substances employed as perfumes.

The nature of this principle is not identical, but it seems to differ, according to the genera of the plants from which it is obtained. Macquer is of the same opinion with Boerhaave, that it is in general composed of an inflammable and a saline substance; but he observes, that it sometimes participates more of the saline nature, and in other plants is more oily. The aroma of cruciferous plants appeared to him to be saline; and he gives it the character of being penetrating, without affecting the nerves. That which, on the contrary, is insipid or

strong, without a keen and penetrating smell, and affects the nerves in such a manner, as either to produce or mitigate those symptoms which depend on their irritation, as is the case with aromatic and narcotic plants, participate more of the nature of oils, according to that celebrated chemist. Several facts may be brought in support of this assertion. The fraxinella emits an odour that forms an inflammable atmosphere around the plant, which immediately takes fire on the approach of an ignited substance; the vapour then burns from the bottom to the top of the stem which supports the flowers. The aroma of fraxinella appears, therefore, to be of an oily nature. Venel, a chemist at Montpellier, and disciple of Rouelle, obtained an acid *spiritus rector* from savoury (marum) by a gentle heat; and Roux, professor of chemistry in the schools of medicine, who examined this product, discovered, that it does not redden blue vegetable colours, but that it saturates alkalis. Chemists are not agreed concerning the nature of the aroma of cruciferous plants. Some think that it is acid, and others imagine it to be alkaline. From the experiments of Deyeux and Baumé, it appears, that sulphur is found combined with the odorous principle of antiscorbutic plants; and that this combustible substance, in the state of an elastic fluid, constitutes the aroma of cruciferous plants.

Two important considerations remain to be offered concerning the aroma. The first is, that this principle, according to the very probable conjecture of Macquer, is probably a gas of a peculiar nature. Its invisibility and volatility, the manner in which it is expanded and dispersed in the atmosphere, together with certain experiments made by Dr. Ingenhousz on the noxious gas afforded by flowers, render this opinion very probable. It only remains, therefore, to make the proper experimental inquiries on this subject, which it must be confessed require the greatest care and accuracy, but at the same time promise to reward the inquirer with discoveries of the most important kind. Boyle has already opened an immense field, and his labours have been continued with the greatest success by Lorry. This philosopher has attended to the alterations which arise from the mixture of odours, and the changes they undergo by fermentation, by the action of fire, of air, or of

different menstua. We cannot, without departing too far from our original plan, enter into any detail of his experiments, and shall therefore only exhibit his primitive division of odours. Lorry divides these bodies into five classes, to which all other odours may be referred; namely, camphorated, etherial, poisonous or narcotic, acid, and alkaline. This physician, explaining the basis of his division, established on the effects of odours on the sense of smelling, and the nerves in general, affirms, that he does not propose to inquire into their chemical nature; but it is most probable, as he himself thinks, that the chemical properties of each class resemble each other, as well as those properties they exhibit in relation to the animal economy.

The second consideration, with which we shall terminate our history of the principle of smell, is, that though the plants called *inodorous* are considered as not possessing it, it is nevertheless well ascertained, that by the lowest heat of a water-bath, these also afford a fluid, whose smell, though feeble, is sufficient to discover the plant from which it was distilled. I can assert, from many experiments, that plants, reckoned most inodorous, such as cicory, plantain, borage &c, afford, by the water-bath, a distilled water, which emits their proper odour, in such a manner as to distinguish them perfectly from each other. These waters are quickly decomposed, losing their faint characteristic smells, and becoming changed by fermentation, which discovers acid or alkaline characters, according to the nature of the substance.

The art of the perfumer consists in extracting the odorous principles of vegetables, and in preserving or fixing them in different substances. Most of the processes of this art are entirely chemical.

Distilled waters are much used in the art of medicine; they possess different virtues, according to their respective nature. Those only are used which are distilled by a naked fire, with the addition of water, as is done in the extraction of volatile oils. We may observe, that this manipulation is advisable in making aromatic essential waters, but is defective with respect to such plants as are commonly called inodorous. We are of opinion, that it is indispensably necessary to distil them

with the water-bath; and as this precaution is not usually taken, they have commonly an empyreumatic smell, instead of that of the plant. If the virtue of these waters reside only in their aroma, feeble as it may be, it is certain, that the usual method of preparing them deprives them of all the properties they ought to have.

We must likewise add, that the distilled waters of plants, prepared in pharmacy, are not the pure aroma, or spiritus rector, in the sense Boerhaave uses the word, but that the aroma is diluted with a large quantity of water, which comes over in the distillation ^a.

NOTES ON CHAPTER XII.

AROMA.

^a FOURCROY, in a memoir inserted in the 26th volume of the *Annales de Chimie*, asserts, that every vegetable matter, whether of an extractive, mucilaginous, or oily nature, may be considered as odorous matter, and that there is no immediate principle separate from the other principles of vegetables which can be properly called spiritus rector, or aroma. Among the immediate principles of vegetables, those which are the most volatile, the most soluble in air, the most expansible, the most disposed to assume and to retain the gaseous form, are in reality the most odorous. These substances are often odorous to such a degree that they may be considered as forming the spiritus rector, or aroma of the plants to which they respectively belong. Fourcroy distinguishes the odours of vegetables into the following kinds:

1. *Extractive or mucous odours*.—They are obtained by distillation without any addition of water from the plants usually called *inodorous*, they are weak, herbaceous, and of short duration. The water which holds this extract or odorous mucilage in solution, becomes muddy, full of mucous flakes, and exhales at the end of some time, the smell of mould. Of this kind are the essential waters of borage, lettuce, plantain, &c.

2. *Oily fugacious odours*.—They are insoluble in water, and do not pass over in distillation. Oxygen destroys them very quickly, they are obtained only by means of the fixed oils which cover the plants in which they are contained. When a little oxygenated, they become soluble in alcohol, but this solution exposed to the air, soon loses its aroma by being oxygenated. Of this kind are the tuberose, jessamine, narcissus, jonquil, sunflower, mignonette, &c.

3. *Oily volatile, aromatic odours, properly so called*.—They are the most abundant of all: They dissolve readily in cold, but more copiously in warm water; they are in part precipitated by cooling, and render the water milky. They are more

soluble in alcohol which takes them from water. The spirituous solution is disturbed by the addition of only a very small quantity of water. Of this kind are the oils obtained from the *labiated plants*.

4. *Aromatic acid odours*.—In addition to the characters of the preceding class, they redden the blue vegetable colours, and often deposit needles of benzoic acid. When deprived of this acid, they resemble those of the third class; some of them seem to contain other acids besides the benzoic. Of this kind are benzoin, storax, balsam of Peru, balsam of Tolu, vanil, canella, &c.

5. *Hydro-sulphureous odours*.—They precipitate metallic solutions of a brown or black colour; they are fetid, blacken silver, and deposit sulphur in the air. Of this kind are those of cabbage, radishes, cochlearia, cresses, &c.

CHAPTER XIII.

OF INFLAMMABLE RESINOUS JUICES IN GENERAL, AND OF
BALSAMS IN PARTICULAR.

THE name of resins is given to dry, inflammable substances, not miscible with water, soluble in oils and alcohol, and which flow in a liquid state from the trees that produce them. These substances are oils, become concrete by being dried in the air. The difference between balsams and resins is not well settled. Some give the name of balsam to fluid inflammable substances, though there are likewise dry balsams. Others call the most odorous inflammable substances by this name. Bucquet has thrown considerable light on this subject, by confining the name of balsams to such combustible matters as communicate a sweet taste to water, and more especially contain an odorant and concrete acid salt, which may be obtained by sublimation or decoction in water.

The principal species of balsams may be reduced to the three following :

1. Benzoin ; this is distinguished into two species, the benzoin amygdaloides, formed of white tears, resembling almonds, united by a brown matter. Common benzoin is brown, and without tears ; it emits a very agreeable smell, when fused or touched with a hot needle. The tree which affords it is not known. Linnæus, the son, calls it *terminalia benzoin*. Murray observes, that the wood and bark of this tree give out the odour of benzoin, whilst burning ; according to this author, it is very doubtful from what tree this balsam is derived. The benzoin comes from the kingdom of Siam, and the island of Sumatra. It affords very little volatile oil on account of its solidity. Boiling water extracts an acid salt, in the form of needles, of a strong smell, which crystallizes by cooling. It is likewise obtained by sublimation, and is then called flowers of benzoin. This operation is made in two glazed earthen pots, placed one above the other, and closed at the place of junction with paper. The sublimation must be performed with

a gentle heat, otherwise the salt will be brown. The paper cone, formerly used as a subliming chimney, instead of the upper pot, causes the loss of a great part of the concrete acid. We have explained the properties of this acid in one of the preceding chapters.

Benzoin, distilled in a retort, affords a very acid phlegm, a concrete and brown salt of the same nature, with a brown and thick oil. The residual coal contains fixed alkali.

Benzoin dissolves in alcohol; and its tincture, precipitated by water, affords the lac virginale. The salt of benzoin, or benzoic acid, is used as a good incisive remedy in pituitous disorders of the lungs and veins. Its oil is discussive, and is externally applied in paralytic disorders, &c.

2. Balsam of Tolu, Peru, or Carthagena. It is imported either in cocoa nut shells, or in yellowish tears, or in a fluid state. It flows from the *Toluifera*, placed by Linnæus in the decandria monogynia. It may be extracted from the shells, by steeping them in boiling water, which renders it fluid. It comes from South America, in the track between Carthagena and Hombre de Dios, called by the islanders Tolu, and by the Spaniards Honduras. By analysing, it affords the same products as benzoin, and more particularly the concrete acid. It is made into a syrup, and is used in disorders of the lungs. Some naturalists distinguish balsam of Peru from that of Tolu.

The acid of these two balsams does essentially differ from benzoic acid.

3. Storax calamita is in tears, either red and clean, or brown and unctuous. Its smell is very strong. It flows from the oriental liquid amber, a plant very little known. Duhamel observed a juice of a similar odour flow from the *aliboufier*. Newman analyzed the storax calamita, and obtained a very small quantity of essential oil, a concrete acid salt, and a thick oil. This balsam is applied to the same uses as benzoin, and is more particularly consumed by perfumers. It was formerly imported enclosed in reeds, or canes; we now receive it in the form of loaves, or irregular masses, of a reddish brown colour, mixed with some tears of a lighter colour, and of a very agreeable smell.

NOTES ON CHAPTER XIII.

STORAX.

^a BOUVILLON LAGRANGE, who has analyzed this substance, says, that it is almost entirely volatile in the fire, and emits an odour similar to that of benzoic acid.

Heated in a pneumatico-chemical apparatus, it affords, 1. An acid phlegm having the agreeable odour of benzoic acid.

2. A white, light, acrid, and penetrating oil.
3. A more deeply coloured, concrete, slightly acid oil.
4. A saline substance sublimed into the neck of the retort.
5. A mixture of carbonic acid and carbonated hydrogen gases.
6. A very light charcoal.

If storax be exposed to atmospheric air, a pellicle is soon formed on its surface which gradually acquires a solid consistence. The storax becomes granular, very bitter and less odorous. It appears to absorb oxygen from the atmosphere, which converts it more completely into the state of a resin. These changes take place more speedily, if oxygen gas be employed instead of atmospheric air.

61,15 grammes of storax macerated for half an hour in 122,28 grammes of distilled water, lost about 1 gramm and a half of its weight. The water had become odorous and acid; by evaporation to dryness, it afforded a white silky light substance which weighed a gramm and a half, reddened blue vegetable colours, was volatilized entirely by placing it on burning coals, was soluble in alcohol, and seemed to agree in its properties with the benzoic acid.

30,6 grammes of quicklime poured into 489,14 grammes of distilled water, were added to 122,28 grammes of liquid storax, and exposed to a gentle heat in an earthen vessel. This mixture was stirred carefully and allowed to boil for a quarter of an hour. When the storax was properly melted, it was taken from the fire and left a moment to deposit; the liquor was then decanted or filtered.

One half of the former quantity of water was added to the storax, and the operation repeated as before. The two liquors being united, were evaporated to one third of their volume and left to cool; muriatic acid was then added to it till no more precipitate appeared, or rather till the liquor contained an excess of acid.

The acid which had been precipitated was placed on a filtre and washed several times with cold distilled water. Very beautiful crystals may be obtained by dissolving it in water and evaporating the solution slowly. From the 122,28 grammes of storax, 7,64 grammes of benzoic acid were obtained.

Alkalis and the mineral acids produce a very marked action on storax. The alkalis unite with the benzoic acid and form benzoates, while the acids dissolve the lime that is found in it and give to it a red colour.

30,6 grammes of storax were digested for 24 hours in 122,28 grammes of alcohol, at the temperature of 10° of Reaumur; when filtered, the liquor had acquired an amber colour, with an aromatic flavour and a pungent taste; with tincture of turnsole it discovered evident marks of acidity. There remained 11,46 grammes

of a residue. By distilling the solution to dryness, a red brown transparent substance was obtained, which had a sweet smell similar to that of benzoin; it weighed 109 grammes.

Water precipitates this substance from its solution in alcohol. If the precipitate be left exposed to atmospheric air, it becomes first brown, and afterwards of a deep red colour.

The residue burns on lighted coals, and emits a slightly aromatic odour. A white earthy substance is left behind. Water has no action on this matter; alkalis give it a deep colour; the sulphuric, nitric, and muriatic acids dissolve the earthy matter; ammoniac forms in it a precipitate which has all the characters of magnesia. Oxalic acid shows in it the presence of lime. *Ann. de Chim.* Tom. XXVI. p. 203.

CHAPTER XIV.

CONCERNING RESINS.

RESINS differ from balsams in their smell, which is less agreeable, and especially in their containing no concrete acid salt; the principal species are the following:

1. Balsam of Mecca, of Judea, of Egypt, of Grand Cairo. It is liquid, white, bitter, and of a very strong smell, resembling that of lemons. It flows from a tree called *amyris opobalsamum*, placed by Linnæus in the octandria monogynia, and discovered in Arabia Felix by Mr. Forskahl. This liquid resin affords much essential oil, by distillation; it is incorporated with sugar, yolk of eggs, &c. and used as a vulnerary.

2. The balsam of copahu, of a brown or yellow colour, which flows from the tree called *copaiba*, or *copaifera*, of Linnæus, and placed by that botanist in the decandria monogynia. The common sort, as well as that of the balsam of Tolu, is a mixture of the true balsam of copahu and turpentine, according to Cartheuser. It is used in ulcers of the lungs and bladder, like the foregoing.

3. Chio turpentine is afforded by the turpentine tree, which bears pistachio nuts. It is of a white, or blueish yellow colour. By the water-bath, it affords a very fluid essential oil; but the oil obtained by a naked fire is less fluid. The turpentine, after this process, is yellower; if the distillation be made with water, it is white and silky, and is called boiled turpentine. This is rarely met with, and is now no longer used.

4. Venice turpentine is commonly used in medicine, either in its natural state, or combined with fixed alkali. This combination is called Starkey's soap, we give it the name of *savonule*. The dispensatory of Paris directs four ounces of volatile oil of turpentine to be poured on half a pound of nitre, fixed by tartar, before it is become cold. The mixture is to be agitated with a spatula of ivory, and the vessel kept covered with a paper, more oil being from time to time added, till the whole forms a white mass. As this process requires seve-

ral months time to complete it, chemists have endeavoured to discover more expeditious methods of performing it. Rouelle, by triturating the alkali, drop by drop with the soap, and adding a small quantity of water towards the end, prepared a considerable mass of this soap in the space of three hours. Baumé directs one part of alkali of tartar, heated till it fuses, to be ground on a levigating stone, three or four times its weight of essential oil of turpentine being gradually added. When the mixture has acquired the consistence of a soft opiate, he exposes it in a moist place, in a glass vessel covered with paper. In fifteen days, the deliquescent alkali forms a stratum of liquor at the bottom of a vessel, the soap is in the middle, and a portion of the oil, of a red colour, floats above. Baumé thinks, that the alkali unites only with that portion of the oil which is in the resinous state. Le Gendre carries this notion farther, and proposes to saturate a cold solution of fixed alkali with oil of turpentine become thick, or turpentine itself. This soap, or *savonule*, has a certain degree of solidity, which gradually becomes more considerable; it affords crystals, which have been considered as a combination of the acid of the oil with the vegetable fixed alkali; but which, according to the academicians of Dijon, consist of the potash, saturated with the carbonic acid and crystallized. As this soap is very difficult to make, and subject to change, Macquer thinks, that when an union of the properties of volatile oils with those of soap, is desired, it is more advisable to incorporate with the white medicinal soap, a few drops of that volatile oil, whose qualities may answer the intended purpose. Ammoniac, triturated with turpentine, forms a saponaceous solid compound, soluble in water, to which it gives a milky appearance.

5. The resin of fir is called *Straßburg turpentine*: it is collected by piercing the vesicles of the bark of fir trees, which grow plentifully in the mountains of Switzerland.

6. Pitch is the juice of a kind of fir, called *abies picea*; it is extracted by incisions made in the bark of the tree. It is melted by a gentle fire, and strained through sacks; after which it is received in barrels. Burgundy pitch is white, but the mixture of coaly matter gives the black colour. When pitch is long kept in fusion with vinegar, it dries, becomes brown, and

forms *colophony*. The dregs of pitch are burned in a fire-place whose chimney leads into a small chamber, terminated by a cone made of cloth: in this last, the smoke condenses, and forms the fine foot, called *lamp-black*.

7. Galipot, or resin of the pine, which affords the soft pine apples. Holes are bored in the lower part of this tree, through which the resin flows into troughs. Other incisions are made higher up, when the former afford no more. When emitted in the fluid state, it is called *galipot*; the portion which dries on the tree, in yellowish masses, is called *barras*. These juices are melted, and when thickened by heat, are filtered through straw mats, and poured into moulds in sand. They then form masses, called *arcançon*, or *bray-sec*. If water be added, the matter becomes white, and forms resin, or *pitch resin*. Galipot is distilled in the large way in the provinces of France, and affords an oil, called *huile-de-raze*, or caulking pitch. The tar, which is the empyreumatic oil of this substance, is prepared with the branches and roots of the pine. The wood of this tree is laid in heaps, covered with turf, and set on fire. The oil, disengaged by heat, not being capable of escaping through the turf, is precipitated into a shallow tub, by means of a channel, and is collected for sale by the name of *tar*.

8. Tacamahaca, resin elemi, resin anime, are very little used: the tree that affords the first is not known. The gum elemi is obtained from a species of *amyris*; the oriental gum anime, or copal, whose origin is unknown, and the occidental gum anime, or courbaril, which flows from the *hymenea*, a tree growing in South America, are used to make varnishes.

9. Mastic is in white farinaceous tears, of a weak smell; it flows from the turpentine tree, and the mastic tree. It is used as an astringent and aromatic, and enters into the composition of drying varnishes.

10. Gum sandarac is in white tears, more transparent than mastic. It is obtained from the juniper, between the bark and the wood. It is likewise called varnish, because it is much used in these preparations. It is used to prevent the sinking of ink into paper, whose external coating of size has been scraped off in making erasures.

11. The resin of guaicum, which is greenish, is used as a

remedy for the gout. It is obtained from the guaicum tree, by incision. Many physicians consider it as a gum resin.

12. The labdanum, or resin of a species of cistus in Candia, is blackish. The country people collect it by means of a staff, at the end of which are fastened many leather thongs, which they gently strike on the trees. They form it into cylindrical pieces, which are called *labdanum in tortis*. It is greatly adulterated by the addition of black sand, and is used as an astringent.

13. Dragon's blood is a red juice, obtained from the *dracena draco*, and several other trees of the same kind. It comes to us in flat or round pieces, or in small balls, wrapped up in leaves. It is used in medicine as an astringent.

CHAPTER XV.

GUM RESINS.

GUM resins are juices mixed with resin, and an extractive matter, which has been taken for a gummy substance. They never flow naturally from plants, but are extracted by incision, in the form of emulsive white, yellow, or red fluids, which dry more or less quickly. Water, alcohol, wine, or vinegar, dissolve them only in part. They differ in the proportion of resin and extract, and their analysis affords various results: the species most necessary to be known are the following:

1. Olibanum consists of yellow transparent tears, of a very disagreeable smell. The tree which affords it is not known. By distillation, a small quantity of volatile oil, together with an acid spirit, are obtained, and the coaly residue, arising from the extractive part, is very considerable. It is used in medicine for fumigations.

2. Galbanum is a fat juice, of a brown yellow colour, and nauseous smell. In Syria, Arabia, and at the Cape of Good Hope, it flows from incisions made in a ferulaceous plant, named *bubon galbanum* by Linnæus. Distilled with a naked fire, it affords a blue essential oil, which afterwards becomes red; and

also an acid spirit, with a ponderous empyreumatic oil. It is a very good discussive remedy, and is powerfully antispasmodic.

3. Scammony is of a blackish grey colour, a strong and disagreeable smell, a bitter and very acrid taste. The Aleppo scammony is distinguished by its greater purity from that of Smyrna, which is ponderous, black, and mixed with foreign substances. It is extracted from the *convolvulus scammonia* of Linnæus. The root of this plant, cut in pieces and pressed, affords a white juice, which is black when dried. The different specimens of scammony contain various proportions of extract and resin, and its medical effects differ accordingly. It is prescribed as a purge, in the dose of from 4 to 12 grains. Mixed with a sweet extract, such as that of liquorice, it forms the common *diagredium*; the juice of quinces is likewise used for this purpose. The common mode of administering it is after previous trituration with sugar and sweet almonds.

4. Gum guttæ is yellow, reddish, without smell, and of a very acrid and corrosive taste. It comes from Siam, China, and the Island of Ceylon. It is extracted from a large tree, not much known, called by the natives *coddam pulli*. It contains much resin, which renders it strongly purgative, in a dose of from 4 to 6 grains. It ought not to be internally used, but with the greatest caution.

5. Euphorbium is in yellow tears, which have the appearance of being worm-eaten; it has no smell. It flows from incisions made in the *euphorbium*, which grows in Ethiopia, Lybia, and Mauritania. It contains a very acrid resin, and is so strongly purgative, that it is reckoned among poisons. It is not used, unless externally, in caries.^a

6. Assafœtida is sometimes in yellowish tears, but most commonly in loaves, formed of a number of pieces, agglutinated together. It has a very fetid smell of garlic, with a bitter and nauseous taste. It is extracted from the root of a species of *ferula*, which grows in the province of Chorason in Persia, and is called *assafœtida* by Linnæus. The root of this plant is fleshy and succulent. By expression, it affords a white juice, of an abominable smell, which the Indians use as seasoning for food, under the name of food of the gods. It is internally used as a

powerful antispasmodic, and is applied externally as a discutient remedy.

7. Aloes is a juice of a deep red or brown colour, and very bitter. It is distinguished into three species: succotrine aloes, hepatic aloes, and caballine aloes: these differ only in their respective degrees of purity, the first being the best. A. De Jussieu saw the preparation of the different kinds of aloes at Morviedro, in Spain, from the leaf of the common aloe plant. Deep incisions are made, from which the juice flows; this is decanted from its fecula, and thickened by the sun's heat, in which state it is packed in leather bags, under the denomination of succotrine aloes. The juice obtained by pressure from the leaves, after it is purified by repose, and dried, is the hepatic aloes. The same leaves, by stronger pressure, afford a portion of juice, which, mixed with the dregs of the two foregoing, constitutes the caballine aloes. The first sort contains a much less quantity of resin than the two last, which are more strongly purgative. It is used in medicine as a drastic purge, and is acknowledged to possess the property of exciting the menstrual flux in women, or the hemorrhoids in men. It is much esteemed as a good hydragogue.

8. Myrrh is brought to us in the form of reddish brilliant tears, of a strong and rather agreeable smell, bitter taste, and exhibiting white lines, of the form of a nail, in their fracture. Some of these tears are entirely gummy and insipid. Myrrh comes from Egypt, and especially from Arabia, in the country of the Troglodites. The plant from which it is extracted is not known. It contains much more extract than resin. It is used as an excellent stomachic, antispasmodic, and cordial remedy. Cartheuser advises literary men, whose stomachs are delicate, to chew this, and swallow it with the saliva. It is used in surgery, either in powder, or dissolved in alcohol, to cleanse foul ulcers, and to stop the progress of caries.

9. Gum ammoniac sometimes has the form of tears, white within, and yellow without, and is sometimes in masses resembling benzoin. They are easily distinguished by their white colour and fetid smell. It is suspected, from the admixture of seed it contains, that this gum-resin, which comes from Africa, is extracted from an umbelliferous plant. The solubility of

this substance in water and in alcohol, and more particularly its inflammability, are properties in which it resembles the resinous-extractive matters of Rouelle.

Gum ammoniac is medicinally used as a discutient remedy in obstinate obstructions; it is given in doses of a few grains, in pills or emulsions, and likewise enters into the composition of many discutient and resolvent plasters.

10. The elastic gum, or caout-chouc, is a vegetable substance, whose nature cannot easily be determined; for though, in its combustible property, which is applied to the purpose of illumination in America, it seems to resemble resins, yet its elasticity, softness, and insolubility in the menstrua which dissolve these last, are characters which show that it greatly differs from them.

The tree which affords this substance grows in several parts of America. Horizontal incisions are made quite through the bark; a white and fluid juice issues forth, which is applied, in successive coats, on clay moulds, and dried by the sun's heat. Various sketches of designs are made on the surface with an iron tool. It is then exposed to the smoke; and when perfectly dried, the clay is crushed and taken out. The bottles, and various utensils of elastic gum, which are imported into Europe, are made in this manner.

Vessels of elastic gum may be used to contain water, and various fluids which do not corrode its substance. If it be cut into pieces, and the newly-cut edges applied to each other, they adhere together with considerable force. I have examined the juice of caout-chouc, which was sent to me from Madagascar. This juice was as white as milk, of an insupportable fetid smell. It contained a white concrete spongy matter, which occupied the middle of the bottle, whose form it had assumed, and which was elastic. By heating the liquor, a white pellicle was soon formed at the surface, consisting of true elastic resin. Alcohol, mixed with the juice, separated this resin in flocks.

The dry caout-chouc, such as it is brought to Europe, exposed to the heat of a fire, softens, swells, emits a fetid odour, and burns at the same time that it shrinks.

Elastic gum is not soluble in water; and the action of saline matters on this substance is not known. Macquer, who at-

tempted to dissolve it in different menstrua, clearly ascertained, that it was not at all acted on by alcohol, as Messrs. De la Condamine and Fresneau had before asserted, in the Memoirs of the Academy for 1751, but that oils dissolve it by the assistance of heat. Nevertheless, as his intention was to liquify, or dissolve it in such a manner, as that it might be used, and resume all its properties, by the evaporation of the solvent, it became necessary for him to use a more volatile menstruum than oils, which remain combined with the gum, and deprive it of its elasticity. Highly rectified ether, which readily dissolves this substance, and may be quickly evaporated, answers the purpose perfectly well. (See the Memoirs of the Academy for the year 1768.) And though this fluid is very expensive, he thinks it may be advantageously used in making certain utensils, such as catheters, by successively applying this solution on a mould of wax, till it is of the required thickness. When it is dry, the wax may be easily separated by immersion in boiling water. The softness and elasticity of this instrument renders it extremely useful for such as are under the necessity of continually using it.

Such was the state of our knowledge, respecting the elastic gum, when, in the month of April 1781, Berniard, well known by the accuracy of his experiments, inserted, in the *Journal de Physique*, an excellent memoir concerning this singular substance. This chemist concluded, from his experiments, that the elastic gum is a peculiar kind of fat oil, coloured by matter which is soluble in alcohol, and blackened by the smoke, to which each coating is exposed to dry. Water does not at all change it; alcohol deprives it of its colour, by boiling. The caustic fixed alkali does not act upon it. Concentrated sulphuric acid reduces it to the state of coal, itself becoming black, and assuming the smell and volatility of the sulphureous acid. The common nitric acid acts in the same manner on this substance as on cork, changing its colour to a yellow. Nitric acid very quickly destroys it, but the muriatic acid does not affect it in the least. Rectified sulphuric ether did not dissolve it. This fact, as the author observes, must appear singular, to all who are acquainted with the exactness and the veracity of Macquer. Nitric ether dissolves it, and becomes yellow,

affording, by evaporation, a transparent friable substance, which is so soluble in alcohol, and is in fact a true resin, formed, according to the author, by the action of the nitric acid on the elastic gum. The volatile oil of lavender, and likewise those of aspic and of turpentine, dissolved it by the help of a slight heat; but they formed gluey fluids, which daubed the hands, and consequently were not applicable to any use. A solution of elastic gum, mixed with alcohol, deposited in oil of aspic, white flocks, insoluble in hot water, at the top of which they floated, and became white and solid, like wax, by cooling: it appeared to be a true congealable fixed oil. Oil of camphor dissolved elastic gum, by simple maceration. By evaporating this solution, the camphor was driven off, and an amber coloured matter, of a firm consistence, scarcely adhesive, remained in the capsule, and was found to be easily soluble in alcohol. Fixed oils, boiled on elastic gum, dissolve it, as does likewise wax. This substance does not melt by the heat of boiling water; but when exposed to a greater heat, in a silver spoon, it is converted into a black thick oil, emits white vapours, and remains fat and adhesive, though exposed to the air for several months, and does not recover the dryness and elasticity in which its chief utility consists. Lastly, Berniard concluded his inquiries, by analysing elastic gum with a naked fire. One ounce afforded a very small quantity of phlegm; an oil, at first light and clear, but afterwards thick and coloured; and in a quantity which he has not ascertained. The coaly residue was similar to that of resins, and weighed 12 grains. This chemist attributes the ammoniac to the foot with which the elastic gum is coloured.

We must observe, that this analysis does not accurately ascertain the nature of elastic gum, because the action of acids on this substance does not resemble that which they exhibit with fat oils, and which is much more rapid; because caustic alkalis do not convert it into soap; because it does not melt, but by a degree of heat much greater than is necessary to melt the most solid fixed oils; because no fixed oil becomes dry and elastic, &c. &c. The author, besides, in his fifteenth experiment, affirms, that this gum is composed of two distinct substances, which he does not exhibit; and he concludes, by considering it as the product of art. From all these reflections, and many

others which may be added, concerning the experiments of Bernard, valuable as they are, we think, with him, that much remain to be done, to ascertain the properties of this substance, and to enable us to decide respecting its nature ^b.

NOTES ON CHAPTER XV.

EUPHORBIA.

CHAPTAL has discovered, that if oxygenated muriatic acid be passed through the white juice of the euphorbia, a very copious white precipitate is produced. The liquor which remains above is limped like water. Two ounces of juice afforded 5 drachms 36 grains of this precipitate. The same, or a similar substance, is formed by long standing, or by the addition of sulphuric or nitric acids. The most remarkable property of this precipitate, is its forming a kind of saponaceous combination with oils. It seems to be in consequence of this affinity for oils, that it decomposes the solution of soap.

This precipitate is insoluble in warm as well as in cold water. It is charred and swells in the fire. Air neither alters its consistence nor colour.

About two thirds of this substance are soluble in alcohol, by the assistance of heat. The remaining part has all the properties of the ligneous fibre. The precipitate seems therefore to be composed of two parts of resin, and one of fibre. These substances are rendered soluble in water, by means of the extractive matter with which they are combined; but oxygen gas, caloric, acids, fixed alkalis, alcohol, and even rest, are capable of separating the precipitate from the extractive matter.

The juices of all the plants similar to that of euphorbia, afforded the same results.

The milk of the emulsive seeds, with the same reagents, seemed to afford the same product. The juices of all the vegetables which Chaptal tried, afforded the same precipitate, differing however in quantity. When obtained by expression or decoction, it was different, for the juices then always contained a quantity of extractive matter.

Grains are the vegetable substances which afforded the greatest quantity of this precipitate.

The similarity of this precipitate with that obtained by the same reagents from milk, is very striking. It was equally insoluble in water, dissolved in oil, and contained fibrous matter. See *Memoires de l'Institut. National*, Tom. I. p. 288.

ELASTIC GUM.

ELASTIC gum, *An. de Chem.* Tom. XI. p. 225. Fourcroy says, that there are five or six vegetables known from which it flows by incision; but that from which it is obtained in the greatest abundance is the *jatropha elastica* of Linnaeus.

From 2 pounds 1 ounce 1 gros of this juice, Fourcroy obtained, by breaking the bottle containing it, 3 ounces 1 gros 36 grains of concrete elastic gum.

The white liquid had a somewhat saline, but acrid and disagreeable taste. By heating it in the open air, a white semi-transparent very elastic pellicle was formed, which had all the properties of the gum. On removing this pellicle several others were successively formed. A pound of the white liquor afforded in this way about 1-half gros of gum. The liquor which had become transparent, was evaporated to the consistence of a syrup; it deposited by cooling, radiated crystals of a yellow colour, and of a saccharine and slightly acid taste. The crystals were very soluble in water, and reddened tincture of turnsole. They dissolved in alcohol and imparted to it a red colour. Elongated white and thin crystals were separated from the alcohol. These did not precipitate the nitric solutions of silver nor mercury, nor form an insoluble salt with lime water. Fire decomposed them, and disengaged pyromucous acid, and carbonic acid gas. They underwent no change from alkaline carbonates. They appeared to Fourcroy to be saccharine matter, about to assume the character of an acid, without being yet converted into that state, from the want of a sufficient quantity of oxygen.

Oxygen gas gradually, and oxygenated muriatic acid speedily, produce a separation of the elastic gum from the white fluid; it is the absorption and fixation of oxygen which appears to give the concrete state to this substance.

Alkalis had an opposite effect, for they produced a more intimate combination of the elastic matter with the liquor, and opposed its separation by atmospherical oxygen.

A liquor slightly acid was obtained from the distillation of this milky juice, but not in a quantity sufficient to determine its nature.

Fourcroy found that sulphuric ether softens, and in part dissolves the elastic gum.

By treating the pure elastic sort with nitric acid, Fourcroy obtained azotic gas, carbonic acid gas, prussic acid gas, and oxalic acid. The same results were obtained from the gum of commerce.

The elastic gum recovers its yellow and brown colour from the contact of air.

Elastic gum has the strongest resemblances in its properties to the gluten, in its elasticity, in giving ammoniac, and a fetid oil in distillation, and in giving azotic gas and prussic acid by the nitric acid. The elastic gum appears to be more oily, and to contain more hydrogen than the gluten.

The plants from which this substance may be obtained, are the *Levæa guineensis* of Aublet, *jatropha elastica*, *cecropia*, *peltata*, *figus Indica*, *levæa caout-chouc*.

Fabroni is said, *An. de Chem.* Tom. XI. p. 195. to have discovered, that rectified petroleum dissolves completely the elastic gum.

CHAPTER XVI.

OF THE PURE FECULA OF VEGETABLES.

THE juices of vegetables, elaborated in their vessels, become thick, and are gradually deposited on the surface of the fibres, which are by that means supported and augmented, or become accumulated, in a more or less solid form, in the organs of the plant. After having treated of the fluid parts of these organized substances, it is necessary to examine the substance of which their solids are composed. We are far from possessing an accurate knowledge of all the solid substances contained in vegetables; but it appears, that when treated by the processes we are about to describe, they are educible into a dry, pulverulent, insipid, white, grey, or variously coloured substance, insoluble in cold water, and of an earthy appearance, called *fecula*.

To obtain this substance, a root, stem, leaf, or seed, is reduced to a pulp, by pounding. Succulent vegetables may be treated in this manner, without the addition of water; but in general water is added, to facilitate the separation of the fibres, and to carry off the divided and pulverized parts. The pulpy matter, by strong pressure, affords a turbid, white, or coloured fluid, which after some time deposits, by standing, a flocky substance partly fibrous, and sometimes pulverulent, which is the true fecula of vegetables. Some parts of vegetables appear to be entirely composed of this matter; such as the seeds of gramineous and leguminous vegetables, tuberous roots, &c. These parts in general afford the finest and most abundant fecula. As to the tender stems and leaves of vegetables, their more fibrous texture affords only a coarse-coloured filamentous deposition, distinguished by the name of coarse fecula. If these be well dried, pulverized and washed, the water carries off a much finer fecula, perfectly similar to that of the tuberous roots, and gramineous seeds. The chemist, therefore, makes no other distinction between these two kinds of fecula, than that the first is obtained from a less fibrous, and less organized part, consisting, as it were, of cells, in which nature has deposited dry

or farinaceous mucilage; while the second, being of a more fibrous texture, requires its organization to be destroyed by a more artificial process.

All the vegetable parts of solids, strictly speaking, afford a kind of fecula: but we shall here more particularly speak of such as are prepared by art for food or medicine. The fecula of bryony, potatoe, cassava, sago, salop, and starch, are those we shall particularly attend to.

1. To prepare the fecula of bryony, the fresh roots are deprived of their bark, rasped in pieces, and submitted to the press. The juice is white, and deposits a very fine fecula, from which, at the end of twenty-four hours, the liquid is decanted, and it is dried. As this fecula contains a certain quantity of extract, left by the juice, it is very acrid, and purges violently: by washing, it becomes finer, and whiter, but at the same time loses its purgative virtue. This method of preparing the fecula of bryony affords but a very small quantity, but a much greater may be obtained, by moistening, with water, the mass remaining in the press, straining this water through a hair sieve, to separate the grosser fibres, and leaving it at rest, and to deposit its fecula, at which time the water is to be decanted off, and the powder dried. This last fecula is not purgative, like the former, because it has been deprived of its extractive matter by the water. Baumé has observed, that the fecula of bryony is absolutely the same as starch, and be made into hair powder, to the great saving of corn. The fecula of the roots of arum, and cornflag, are prepared in the same way for medical uses.

2. Potatoes are amongst the most useful alimentary substances, with respect to their abundance and fertility. They afford a large quantity of very fine white fecula, which, when boiled, is an excellent food. It is obtained by scraping the potatoes into a sieve, and pouring thereon a large quantity of water. The fluid carries off the finest and most divided part of the fecula, which subsides by standing. The water is decanted off, and the fecula, dried by a gentle heat, has the form of a very fine white powder. Mills, consisting of a kind of rasps, turning on cylinders, have been contrived, and are used to great advantage in preparing this fecula.

3. The Americans extract, from the root of a very acrid

plant, called *manioc*, a mild nourishing fecula, which they call *Cassava*. They strip the root, rasp it, and put it into a sack of rushes, made in the form of a cone, and of a very open texture, which they suspend to a staff, placed across two upright posts. At the lower extremity of this sack, they hang a heavy vessel, which by its weight presses the root, and receives the juice which flows out, and is a most acrid and dangerous poison. When the fecula is well pressed, and deprived of its juice, it is dried in the smoke, sifted, and then forms cassava. This farina is spread on a hot plate of iron, and turned till both its surfaces acquire a reddish yellow colour, which denotes that it is sufficiently baked. In this state it is called *cassava bread*. When the farina is heated in a vessel, and agitated from time to time, it takes the form of grains, called *couac*. A very fine and mild fecula, called *mouffache*, falls to the bottom of the expressed juice, and is used for pastry.

4. Sago is a dry fecula, reduced into grains by the action of fire, and comes to us from the islands of Molucca, Java, and the Phillipines. It is obtained from a kind of palm, called *landan*, in the Moluccas. The trunk of this tree contains a sweet pith, which the inhabitants take out after having split the wood: they then bruise it, and put it into a kind of cone, or funnel, made of bark, and pour on a large quantity of water. This fluid carries with it, through the sieve, the finest and whitest part of the pith, the fibrous part remaining behind. The water is received into pots, and gradually deposits the fecula. The clear water is then decanted, and the deposited matter is passed through perforated plates, which give it the form of small grains. The red colour on their surface rises from the action of fire, used in the drying. These grains, or sago, become soft and transparent in boiling water, and form, with milk or soup, a light and agreeable liquid, which is strongly recommended in phthysical disorders.

5. Salep, salop, salab, &c. is the root of a species of orchis, prepared by the orientals. They select the finest bulbs of this plant, which they peel, and boil, after previously soaking them in cold water. They are then strung, and dried in the air. M. Jean Moulton describes another process for preparing salop, which may be used with every kind of orchis. The roots,

either dry or under water, are rubbed with a brush, to take off the external pellicle; after which, by drying in an oven, they become very hard and transparent. These are very easily reduced into powder, which, with hot water, forms a nourishing jelly, much praised by Geoffroy, in all disorders arising from an acrid state of the lymph, and especially in consumptions, and the bilious dysentery.

CHAPTER. XVII.

CONCERNING THE FARINA OF WHEAT AND OF STARCH.

STARCH, properly speaking, is a fecula absolutely similar to the foregoing; but as the farina of corn, of which it is a constituent part, is one of the most important substances that come under the examination of the chemist, we shall treat more fully on this than on the other fecula.

The substance called *flour*, is in general dry, friable, insipid, capable of acquiring taste and digestibility, by the action of fire, and composed of several substances easily separable from each other. It exists in the seeds of gramineous plants, more especially wheat, rye, barley, oats, rice, buckwheat, &c. Leguminous plants likewise appear to contain a compound analogous to flour; but the flour of wheat only can be said truly to possess the requisite properties, because it is the only farina in which the different substances are duly proportioned to each other. Though the economical use of the flour of wheat, as the principal article of nourishment, has been established from time immemorial, it is but lately that chemists have begun to examine it. Messrs Beccarri, an Italian physician, and Kessel Meyer, in Germany, are the first chemists who endeavoured to separate the different substances contained in flour. Messrs. Rouelle, Spielman, Malouin, Parmentier, Poulletier, and Macquer, continued and carried the experiments of these philosophers much farther. Parmentier, especially, has prosecuted this inquiry with uncommon zeal and activity. His researches into the nature of alimentary substances, the component parts of flour, the different species of fecula, and on all nutritive ve-

getables in general, are, without doubt, the most complete and exact of any that have been made in this way.

Water is an agent of the greatest utility, and least capable of altering the several matters it takes up, or separates, in the order of their solubility. This fluid is used, with the greatest success, to obtain the different substances of which wheat flour is composed. To perform this true analysis, a paste is made with flour and water, and kneaded in a vessel of water, underneath a stream from a cock; the water carries off a very fine white powder, and the kneading must be continued till this fluid passes off clear. The flour is then found to be separated into three substances; a greyish and elastic matter remaining in the hand, which has been called the glutinous, or *vegeto-animal* part, on account of its properties; a white powder, deposited by the water, which is the fecula, or starch; and a substance, held in solution by the water, which appears to be a kind of mucous extract. We shall examine the properties of each of these three substances in order.

§ I. *Concerning the Glutinous Part of Wheat.*

The glutinous part, is a tenacious, ductile, elastic matter, of a whitish grey colour. When drawn out, it extends about twenty times its length before it breaks, and appears as if composed of fibres, or filaments, placed beside each other, according to the direction in which it has been drawn. If the force ceases, it resumes its original form by its elasticity. By drawing it out, in different directions, it may be made so thin, that its polished surface resembles the texture of animal membranes. In this state it adheres strongly to dry bodies, and forms a very tenacious glue, which was used by some persons to join broken china, long before chemists found the means of obtaining it in large quantities. Beccari has observed, that the proportion of glutinous matter is from a fifth, to a third, and more, in flour of the best quality; he has likewise observed, that this quantity varies in different seasons, and according to the nature of the corn.

The smell of the glutinous matter is faint, and resembles that of mucilage; exposed to a fire capable of suddenly drying it, it swells up prodigiously. In a dry air, or mild heat,

it dries very well. It is then semi-transparent, and hard, like glue, and snaps short like that substance.

If in this state it be placed on burning coals, or applied to the flame of a candle, it exhibits all the characters of an animal substance; it decrepitates, swells, liquifies, curls up, and burns like a feather, or a piece of horn, emitting, at the same time, a strong and fetid smell. By distillation, it affords, like animal substances, water, impregnated with ammoniac, ammoniacal carbonat, and an empyreumatic oil. Its coal is very difficultly incinerated, and does not contain fixed alkali.

Fresh gluten, exposed to a hot and moist air, becomes changed, and putrifies absolutely in the same manner as animal substances. When it retains a small quantity of starch, this last passing to the acid fermentation retards and modifies the putrid fermentation, and converts the substance into a state nearly similar to that of cheese. Rouelle the younger prepared a cheese with the gluten, which singularly resembled in its smell and taste, that of Gruyere, or of Holland.

Water does not at all dissolve this glutinous matter. By boiling in this fluid it becomes solid, loses its extensibility and adhesive quality, but does not acquire either taste or solubility in the saliva. Nevertheless, we must observe, that the gluten owes its elasticity and solidity to the water which formed the paste. In fact, this vegeto-animal portion, though capable of becoming solid and elastic, is pulverulent, and without cohesion in the flour; but as soon as water is added, its particles absorb the fluid, and adhere together, forming the elastic substance called *gluten*. Water, therefore, contributes greatly to the formation of this substance, and it may perhaps be considered as a compound, saturated with, and incapable of absorbing a larger quantity of water. This is so true, that it absolutely loses its adhesion and elastic properties by drying.

Most saline substances act more or less efficaciously on the gluten. The caustic fixed alkalis in the fluid state dissolve it by boiling. This solution is turbid, and deposits, by the addition of acids, a gluten which is not elastic.

The mineral acids dissolve the gluten. The nitric acid dissolves it with great activity, and Berthollet has observed, that this acid disengages azotic gas, as it does from animal substan-

ces. When this elastic fluid has been emitted, the solution affords a large quantity of nitrous gas, and becomes of a yellow colour. By evaporation it affords crystals of the oxalic acid. The sulphuric and muriatic acids form brown or violet solutions of this substance, from which a kind of oily matter separates; the gluten being truly decomposed. Poulletier, who has made many experiments on this substance, has discovered, that ammoniacal salts may be obtained from these combinations, dissolved in water, or spirit of wine, and evaporated in the open air.

From these facts, it follows, that this substance is totally different from all those hitherto known in vegetables, and that in many of its characters it resembles the fibrous part of the blood. It is to this gluten that wheat flour owes its property of forming a very adhesive paste with water, and the facility with which it rises in leaven. The gluten does not appear to exist, at least in any considerable quantity, in other farina, such as that of rye, barley, buckwheat, rice, &c.; all which form solid, opaque pastes, scarcely ductile, easily broken, and which do not ferment when exposed to the temperature by which that process is effected in wheat paste. The presence of the gluten appears therefore to be necessary for the production of good bread.

Berthollet thinks that this glutinous substance contains phosphoric salts, like animal matters, and that this is the cause of the difficulty with which its charcoal is incinerated. Rouelle the younger found a glutinous substance analogous to that of wheat in the green fecula of plants, which afford ammoniacal carbonat and empyreumatic oil, as does the vegeto-animal substance here treated of^a.

§ II. *Concerning the Starch of Wheat.*

Starch, or the amylaceous fecula, composes the greater part of flour; it is the white substance which subsides from the water used in obtaining the pure gluten. This substance is very fine, and soft to the touch; its taste is scarcely sensible. Its colour is of a grey and dirty white, when extracted by the process we have described; but the starch-makers render it extremely white by suffering it to remain in an acid water for

a time, which they call the *four water*. It appears from the experiment of Poullétier, that the fermentation which takes place in this fluid, whitens and purifies the starch by attenuating, and even destroying the extractive mucous substance with which it is vitiated at first. Starch, chemically considered, is a mucilage of a peculiar nature. This mucilage, which has been improperly considered as an earth by some chemists, differs greatly from the glutinous part. It burns without emitting an empyreumatic smell. By distillation with a naked fire, it affords an acid phlegm, of a brown colour, and a very thick empyreumatic oil towards the end. Its coal is easily reduced to ashes, which contain fixed alkali.

Starch is not soluble in cold water, but when boiled in water, it forms a kind of glue, that, when exposed to a moist air, gradually loses its consistence, ferments, becomes four, and at last mouldy.

The nitric acid produces the oxalic acid with this fecula, which is perfectly similar to those we have treated of in the foregoing chapter.

As starch forms the greatest part of flour, it cannot be doubted, but that it is the principal alimentary substance contained in flour, and in bread^b.

§ III. Concerning the *Mucous Extractive Part of Flour*.

By evaporating the pure water with which the paste was washed, and from which starch had been deposited, Poullétier obtained a viscous gluey substance of a brown yellow colour, and slightly saccharine taste. This substance, denominated by its discoverer the *mucofo-saccharine* matter, exhibited all the phenomena of sugar in its combustion and distillation. It is this which excites the acid fermentation in the water that floats above the starch; for, as Macquer well observes, the latter is not at all soluble in cold water.

The mucofo-saccharine matter exists in a very small proportion in the farina of wheat, but may perhaps be more abundant in other kinds of flour.

It cannot be doubted, notwithstanding the small quantity of this substance contained in the farina of wheat, but that it is principally concerned in the fermentation by which paste is

leavened and made to rise. This intestine motion, so necessary in the making of good bread, is not yet well understood. It may perhaps consist in the commencement of fermentation, which is putrid in the gluten, acid in the starch, and perhaps vinous in the mucofo-faccharine matter; and from these three incipient fermentations mutually impeding each other, the lighter compound, which by baking forms bread, may probably arise. At all events, it is certain, that the three substances we speak of are so combined and altered in bread, that they can no longer be separated. The action of heat is sufficient, without fermentation, to produce this intimate combination; for unleavened bread, according to Malouin and Poulletier, does not afford the glutinous matter.

From the foregoing facts we see, how greatly other kinds of flour differ from that of wheat, and still more those leguminous and farinaceous feeds, such as beans, pease, chefnuts, &c. are far from possessing the qualities necessary to make good bread.

NOTES ON CHAPTER XVII.

VEGETABLE ALBUMEN.

^a FOURCROY, observing that a matter coagulable by heat was separated from juice of cochlearia, cresses, &c. along with the colouring matter, took 2 lbs. of the juice of the young cresses, and filtered it in the cold. The coarser part of the fecula was separated in this way. The liquor was of a clear green colour. Exposed to the air in a flat vessel, in two hours the liquor became muddy, and a finer green fecula than the first was disengaged, which was separated by filtering it. The ley was now of a pale green colour. When poured in boiling water, a coagulation took place of a great number of small whitish flocks; similar flocks appeared in another portion of this juice, which had been left exposed to the atmosphere; and sulphuric acid separated a similar matter from a third portion. The substance obtained in these three different ways, washed in water, exhibited all the properties of animal albumen. *Ann. de Chem.* Tom. III. p. 252.

It dissolved in alkalis, was rendered more solid by boiling water, gave a green tinge to blue vegetable colours, and afforded ammoniac in distillation; with moisture in a warm atmosphere, it exhaled a fetid ammoniacal smell, and exhibited every symptom of putrefaction. This enables us to understand why the cruciform plants are so readily decomposed. Dried in the air, this substance assumed the ductility and transparency of glue.

Fourcroy obtained a similar albumen from the juice of cabbage and cochlearia. The root of patience contains a remarkably large quantity of albumen.

If the water used to separate the farina from the gluten of wheat be filtered, and afterwards exposed to heat, white flocks of a concrete matter will be separated, which possess all the properties of albumen. So that wheat contains two substances; one, the gluten similar to the fibrous part of animals, and another similar to the albumen. This last exists in all green plants, and in all their soft and succulent parts. It appears to be condensed and thickened in the process of vegetation, and to contribute to the formation of the solid parts. Dry wood does not afford any of it.

It is to the existence of this principle that an infusion of wood owes its fetid and ammoniacal smell. Wood, according to Fourcroy, that has been steeped in water, does not afford so much ammoniac as new wood.

All acid vegetable substances, and particularly fruits, contain, instead of albumen, the substance called gelatin; such as the juices of the orange, citron, gooseberry, &c. Fourcroy having perceived that the albumen of the blood affords a kind of gelatin, soluble in water by the nitric, muriatic, and acetous acids, imagines that the albumen which exists in young vegetable substances without any acid may be converted into the gelatinous matter, by combination with the acids which are formed during the process of vegetation.

Animal gelatin has a strong tendency to become acid, and a small quantity of oxygen only is required to give it the acid character. Fourcroy asks, Is it not probable, that gelatin differs from albumen, only in containing a greater quantity of oxygen?

In distillation, vegetable albumen affords ammoniacal carbonat, a red fetid oil, and carbonated hydrogen gas; with a residue of light, difficultly combustible charcoal, in too small a quantity to be examined by Fourcroy.

STARCH.

b CHAPTAL first remarked, that if diluted nitric acid be digested on fecula, the acid is decomposed, and the fecula passes to a state resembling that of the ligneous fibre.

My friend Mr. Jamieson of Leith, in a paper which he read some years ago to the medical society of this place, gave an account of some very singular results which he obtained, by digesting starch in muriatic acid. This acid, when concentrated and colourless, dissolved starch in a temperature equal to 90° of Fahrenheit. By increasing the temperature, the solution acquired a brownish colour, and at length a brownish black precipitate was formed, which seemed to possess all the properties of charcoal. On adding caustic soda to the liquor, and subjecting it to evaporation, a small quantity of acetit of soda was obtained. By distilling the muriatic acid from starch, a carbonaceous residue was obtained, which inflamed readily with nitric acid, and which in some cases was so inflammable, as to take fire by simple exposure to the air.

CHAPTER XVIII.

CONCERNING VEGETABLE COLOURING MATTERS, AND THEIR
APPLICATION TO THE ART OF DYING.

VEGETABLES contain colouring matters in all their organs. These parts differ greatly from each other; for a vegetable substance, which has no apparent colour, often assumes a very evident tinge, by peculiar menstua. The art of dying, all the processes of which are absolutely chemical, is founded on the solubility of colouring matters in different menstua, the method of applying them to substances proposed to be dyed, and of rendering them fixed. In treating of the properties of each colouring matter, we shall have occasion to speak of the principles of this important art, which is excellently treated of in the works of Hellot, Macquer, Le Pileur d'Apligny, Hecquet d'Orval, the Abbé Mazeas, and particularly of Berthollet.

The colouring matter of vegetables properly so called, is not yet well known. Rouelle supposed that the colouring matter, which is so abundant in the vegetable kingdom, was analogous to the gluten of flour; but it is certain, that this matter presents different chemical characters, according to the base with which it is united. When, therefore, it is said, that a colour is extractive, resinous, &c. the terms apply rather to the base, than to the colouring matter. The true colouring matter of vegetables used in the arts, is doubtless of a very subtle nature, and is perhaps as divisible as the principle of smell. It may even be supposed, that it consists only in a peculiar modification of the solid and liquid parts of vegetables.

It is necessary to repeat in this, that the colour of vegetables is for the most part produced by the contact of light; but the manner in which light produces this effect, is a problem not yet solved. However this may be, as it is impossible to separate the colouring matter entirely from the vegetable base it adheres to, these two substances are usually taken together for the colouring matter.

No chemist has more accurately distinguished the vegetable colouring matters, considered with respect to the art of dying, than Macquer; and his theory concerning the applying and fixing these colours to substances intended to be dyed, must be admitted as highly satisfactory. As it is our intention to connect this theory of dying with the history of the chemical properties of vegetable colouring matters, we shall consider them in the same point of view.

1. A great number of vegetable colouring matters, which are of an extractive or saponaceous nature, are readily dissolved in water. Bastard rocket, madder, logwood, redwood, and Brasil wood, afford yellow or red colours of this kind. It may be easily conceived that substances tinged with these matters, readily give out their colour to water; and it is therefore found necessary, in order to render them durable, to make use of some additional substance capable of decomposing and fixing them; as for example, red tartar, alum, and other salts. These salts are called *mordants*. A disengaged acid would produce the same effects, but it would alter the colouring matter. The portion of superabundant acid of the alum unites with the alkali of the colouring saponaceous extract, and causes the resinous part, which is then insoluble in water, to be precipitated on the substance intended to be dyed. However, this colouring portion, rendered insoluble by the alum, or the mordant, is of two kinds; the first is very solid, and resists the air, soaps, and all the liquors which dyers call *proofs*. This kind of colour is called a *good or strong dye*. The other is changed by the air, and especially by the action of the proof liquors: It is called a *false dye*. To discover the nature of these colours, and the duration of dyes in general, Berthollet proposes the use of the oxygenated muriatic acid, which in a very short time, by its excess of oxygen, produces the same effect as the pure air of the atmosphere would effect in a much longer space of time. The quantity of acid required to discolour and entirely bleach any dyed stuff, as well as the time required for this purpose, may serve to determine the solidity and duration of colours.

It is observable that wool takes the dye better than any other substance; and that silk, cotton, and flax, in the order we

have mentioned them, are dyed with more difficulty, and retain the colouring substance more weakly.

Writers on the art of dying, hold different opinions respecting the manner in which the colouring parts apply themselves to the substances exposed to their contact. Many have supposed that this application takes place only in proportion to the number and magnitude of the pores in the various substances; and that wool takes the dye better than silk or thread, because its pores are more open and numerous. But Macquer thinks, that the greater or less facility with which the colour is applied, depends on the respective nature of the colouring parts and the substance proposed to be dyed; and that the art of dying is truly an external tinge or painting, which succeeds and lasts by virtue of an affinity and intimate union between the colour and the dyed substance. This celebrated chemist adopted this opinion in consequence of the numerous experiments for which this art is greatly indebted to him.

2. Another kind of colouring matter seems to be composed of saponaceous extract and resin. Macquer calls them *resino-terrestrial* matters. When these matters are boiled in water, the resinous substance they contain melts, and is dispersed in the fluid by the assistance of heat, and by virtue of the dissolved saponaceous portion; but it precipitates in proportion as the decoction or bath becomes cold. Consequently, when wool, or any other substance is plunged in a decoction of this nature, the resin separates by cooling, and applies itself without any other preparation; and as it is not soluble in water, it forms a lasting dye. Colouring matters of this class are obtained from almost all astringent vegetables, such as the husks of nuts, roots of walnut-tree; or of dock, fumach, bark of alder, sandalwood, &c. These colours are all yellow, and are called root colours by the dyers. They generally serve to form a very good ground, on which other more brilliant colours may be applied. It may be observed, that colouring ingredients, which require no preparation either in the bath, or in the stuff to be dyed, are more easily applied to use than others.

3. The colouring principle of many other substances resides in a purely resinous matter, insoluble in water, and some not

even in alcohol ; but they all are soluble in alkalis, which convert them into a kind of soaps, soluble in water. The principal colours of this nature employed in dying are the following.

A. The annato, a kind of fecula, obtained by maceration of the seeds of the *urucu* putrefied in water. This fecula deposited during the putrefaction, is first red, and in process of time becomes of a brick dust colour. The paste is mixed in water with the alkali of *cendres gravelees*, shortly to be described, and forms a bath, wherein the stuffs intended to be dyed are plunged. A gold, or orange yellow colour, of considerable beauty, is deposited without the assistance of a corrosive.

B. The flower of carthamus, or bastard saffron, affords a very fine red colour, by the same process. It contains two distinct colouring parts ; the one purely extractive and soluble in water, the other resinous. In order to obtain the latter, the soluble part of the carthamus must first be carefully washed away. The remainder is mixed with the *cendres gravelees*, or salt of soda ; and the mixture being lixiviated, forms a bath. But as the alkali alters the colour, and renders it dull, the dyed stuff is plunged in water rendered acid by lemon juice : the acid seizes the alkali, and leaves the colouring matter, which it enlivens, and causes to become red. A coloured fecula is obtained by a similar process, which, mixed with briançon chalk in powder, composes the rouge used by the ladies.

C. Archil is a paste prepared with mosses and lichen macerated in urine with lime : The latter disengages the ammoniac, which develops the red colour. Archil mixed with water, affords a dye without any other preparation ; with alkalis, it strikes a violet colour ; but this is a false dye, which changes in the air, and becomes yellow by the action of acids.

D. Indigo, which is of a deep violet blue, of a coppery tinge, is a fecula prepared at St. Domingo, and in the Antilles, &c. by macerating the stalks of the *anillo*, or indigo plant, in stone troughs, with water. The water becomes blue, and after strong agitation the fecula precipitates. The indigo separated from the water, is put into cloths to drain, and after being dried in small wooden boxes, it is broken into pieces. It is

esteemed good when it floats on water, and burns entirely away on a red hot shovel. The colouring matter is extracted by alkalis, and applied, without any other preparation, to the stuffs. It cannot be brightened by acids, because they change its colour.

4. Certain colouring substances are soluble in oils. Alkanet, or the red root of a kind of bugloss, communicates its colour to oil. Alcohol likewise dissolves several colouring matters: green fecula dissolve in this menstruum, as well as in oil. It may easily be conceived, that these colours are not used in dying, because the liquids necessary to extract them cannot be employed.

Such are the principal circumstances in which our knowledge of vegetable colours consists. Every immediate principle of vegetables may constitute the base of these colouring parts, since they are found of saponaceous, resinous, and extractive kinds. Some even appear to be of the nature of fixed oils, being insoluble in water, or alcohol, though they readily dissolve in alkalis. Lastly, there are some which are analogous to the glutinous part, according to Rouelle.

All vegetable colouring matters, have a stronger or weaker attraction for oxygen; for there are few of them, which are not more or less, speedily altered by this principle. The oxygenated muriatic acid, alters almost the whole system, and converts them to white or yellow. The greater part of vegetable colours, contain different proportions of oxygen, and frequently owe their shades to a difference in the quantity of this principle. Because, the air has a singular effect on their dyes, all their colouring matters are prepared with the contact of air. See a memoir by Haussmann on Indigo, (*Journal de Physique* 1788) and my memoir on the Colouring of Vegetables by Oxygen, *An. de Chem.* Tom. IV.

NOTES ON CHAPTER XVIII.

COLOURING MATTER.

Hausmann suspects that madder contains a peculiar acid. He found that durable colours were produced, by adding carbonat of lime to an infusion of madder. During the combination of the colouring matter with the lime, a portion of carbonic acid was disengaged: the colours resisted the action of the muriatic acid, alkaline leys, and soap. *An. de Chem.* Tom. X. p. 362.

Dr. Bancroft remarks, that indigo seems to consist chiefly of a particular vegetable basis, united to a large portion of oxygen, to which its colour is principally owing, and for which it has a strong attraction.

Water dissolves the mucilaginous, and some of the adventitious parts of indigo. Alcohol dissolves others, but neither can dissolve any part of its colouring matter. There are but two ways in which indigo can be dissolved; the first of these is by means which attack its basis, by superadding a farther portion of oxygen; the other is by substances which absorb and take away from indigo a considerable part of the oxygen combined with it, so as thereby to render its basis liable to be acted upon, and dissolved by the pure, or caustic alkalis.

In the first of these ways, fire speedily decomposes indigo. The nitric acid also, when concentrated, attacks it so powerfully as to produce actual ignition; and, even when diluted, it not only destroys the blue colour immediately, but dissipates the greatest part of its substance by a slower combustion; leaving behind it a rusty, iron coloured, gummo-resinous mass, soluble in alcohol, and partly so in water, but of no use.

Indigo reduced to powder, and mixed with five or six times its weight of strong sulphuric acid, will be attacked with considerable activity and heat, and in about twenty-four hours will be dissolved. When acted upon by this acid, the colour of the indigo is rendered more lively and beautiful, by the addition of a farther portion of oxygen, though it becomes less durable.

The muriatic acid, in its most concentrated state, has no sensible action upon the pure colouring matter of indigo. It is rapidly dissolved by nitro-muriatic acid, and its colour destroyed nearly in the same way as by the nitric acid alone. Neither sulphuric nor nitric acid, when greatly diluted, are capable of dissolving the colouring matter of indigo.

The oxygenated muriatic acid acts but very feebly on indigo whilst in substance, but when dissolved, it destroys the colour. By adding a little oxyd of manganese to the solution of indigo in sulphuric acid, the blue colour of the indigo is destroyed as efficaciously, and in the same way as by oxygenated muriatic acid.

The tartareous, acetous, phosphoric, fluoric, and other acids, seem to have no action on the colouring matter of indigo.

None of the alkalis, whether mild or caustic, have any action upon the colouring matter of indigo, unless when it has been previously dissolved by sulphuric acid, or deprived of a portion of its oxygen.

In the second and only way of dissolving indigo, without lessening the durability of its colour, there is no one substance or agent in nature, capable of producing this effect, but it results from the concurrent action of several agents.

Woad alone dyes a blue colour very durable, but less vivid and beautiful than that of indigo; it is therefore at present never used except with indigo, in what is called the woad vat; in which it is made to ferment with water, by a suitable degree of warmth, and the addition of bran with other vegetable matters; to these, indigo and lime are afterwards joined; and the indigo, being deprived of a portion of its oxygen by the fermenting vegetable substances, is therefore rendered soluble by the lime, and, being in this way soon combined with the colouring matter of woad, both form a dying liquor, blue, or copper coloured on the surface, where it can re-absorb the oxygenous gas, but green immediately beneath the surface, and throughout the whole mass. When the liquor becomes fit for dying, and cloth or wool dyed with it, though they appear green when taken out, they become blue immediately, by attracting and combining with the oxygen; the loss of which had previously rendered the liquor of the woad vat green.

There are various other blue vats in which the indigo is dissolved, and made fit for dying; but in all of these, the indigo is first deprived of a portion of its oxygen, by the attraction of the vegetable or animal ferments, or of the oxyd of iron, and then it is dissolved, either by lime, or by some alkali. See Dr. Bancroft's *Experimental researches concerning the Philosophy of Permanent Colours*, 1794, Lond.

Bouillon la Grange obtained a substance similar to the adipocire of the cements, by passing oxygenated muriatic acid gas into an infusion of fenna leaves. This substance had a citron, yellow colour, was insoluble in water, but soluble in alcohol. On lighted charcoal it burned with a thick, slightly aromatic smoke, and left behind it a light and insipid charcoal. A similar substance was obtained by oxygen gas. This chemist obtained the same substance, by treating the leaves which had been boiled in water with some alkali; by which they acquired an intensely purple colour. The solution saturated with a diluted acid, and evaporated to dryness, besides the neutral salt, afforded a fawn brown coloured substance, which possessed all the characters of that obtained by oxygenated muriatic acid.

The fenna leaves, treated with alkali, have a deep green colour, which may be taken up with warm alcohol. This solution, by evaporation leaves a green matter in the vessel, which is not miscible with water, and which is not soluble in alkalis. The oxygenated muriatic acid deprives it in a short time of its colour. *An. de Chem.* Tom. XXIV. p. 8.

Mussin Puschkin has observed, that oleo-colorants, or cero-colorants are formed by decomposing soaps with the acid extracts of colouring matters; such, for example, as the extract of Brazil wood by diluted acetic acid. The colours are extremely brilliant. *An. de Chem.* Tom. XXIV. p. 214.

Fabroni has discovered a violet purple colour in the juice of the socotrine aloes, which is improved rather than injured by exposure to the air. *An. de Chem.* Tom. XXV. p. 299.

A new dying wood, called *paraguanan*, brought from Guian, is said to possess very advantageous qualities. The decoction of the bark affords a colour which resists the action of the sulphuric, nitric, and muriatic acids longer than the colour of Brazil or Campechy wood. It can also be revived in alkalis, after it has been made to disappear with acids. Vinegar, lemon juice, and cream of tartar, render this colour more brilliant, while they destroy that of Brazil or Campechy wood,

The fecula of the paraguatan attaches itself to wool, cotton, and silk. The colour of the silk is most brilliant, that of the cotton least so.

This fecula, when dried, is capable of being dissolved in alcohol, to which it communicates a colour similar to that of cochineal. A decoction of this substance forms, by mixing it with alum, a kind of lac, which is not so beautiful as that obtained from cochineal by a similar process. This decoction, mixed with that of nut-galls, forms a precipitate of a weak rose colour.

The colour from the paraguatan is not equal in force to that from cochineal, but it is superior to those of Madder, Brazil, and Campechy.

Morveau is of opinion, that the red colour of fruits is produced by the reaction of their acids upon the colouring matter which they contain.

Tin, therefore, according to this hypothesis, in reviving or restoring the colour of violets, does this merely by its affinity for the acid. This effect is produced also by the oxyds of lead, bismuth, antimony, zinc and iron. The metallic oxyds, which appear to act most readily on vegetable colouring matters, are those which retain these matters most feebly. Oxyd of tungsten has, in this respect, a decided advantage over all others, by forming lacs which are extremely useful in painting and dying, which are not altered by the reagents that destroy vegetable colours. *An. de Chem.* Tom. XXX. p. 185.

To extract the colouring matter of lichens, Westring recommends one part of lichen to be macerated with a tenth of quicklime, and a twelfth part of muriat of ammoniac. In some species of lichen, maceration in the cold is sufficient to extract the colouring matter; but the developement of the colouring particles is much aided by heat. Some lichens require even boiling, in order to be made to part with their colouring matter. The chemical changes which take place during the developement of the colouring matter in this process, seem to be but little known. During the first days of maceration, it is said to be serviceable to exclude the external air. *An. de Chem.* Tom. XV. p. 267.

Berthollet found, that 100 grains of the colouring matter of lint, is soluble in 50 grains of caustic potash. 50 grains of the carbonat of potash dissolve about 1-4th less of this colouring matter, and form with it a triple combination. Lime-water produces a copious precipitation in an alkaline solution of this substance. Metallic solutions also occasion precipitates, which vary extremely in their colours. Lint contains from 1-4th to 1-3d of this colouring matter, only a small portion of which is in a state to be dissolved by an alkali. Hence, according to this author, arises the necessity of alternately exposing lint, in bleaching, to the action of the air, dew, or oxygenated muriatic acid, and to that of alkaline lixiviums. This matter affords, by distillation, a thick oil, a little ammoniac, and 24-100dths of carbon. During the distillation, carbonic acid and carbonated hydrogen gas were disengaged; so that carbon must have formed a large proportion of this matter.

From a variety of experiments this chemist concludes, that all vegetable colours are discharged, or converted to a yellow, by the action of oxygenated muriatic acid.

That during this discolouration, the oxygenated acid passes to the state of ordinary muriatic acid.

That the vegetable matters deprived of colour had combined with oxygen, and had been deprived of their colours only by an excess of that principal acid. And,

That, consequently, the oxygenated muriatic acid may be employed as a test of the fixity of colours and dyes.

Fourcroy thinks, that oxygen has a decided influence in producing and in alter-

ing vegetable colours. Stuffs dyed with indigo are green when first taken out of the dying-vat, and become blue only by the contact of air. The black dye of wool acquires its true state only by exposure to the atmosphere. Byffi and mushrooms, which grow in the dark, are white, but afterwards become coloured in the air. Some infusions and vegetable decoctions acquire a deep colour by the contact of the air. In the discolouration produced by the oxygenated muriatic acid, the shades of some of the colours are first heightened, and some of them remain more or less fixed, after having absorbed a quantity of oxygen. The effect of air in colouring vegetables, is evident in the production of the green colour, and in modifying the colours of the flowers of plants. The fecula of indigo and pastel assume a blue colour only from the absorption of oxygen. The addition of a small quantity of muriatic acid converts a blue colour to a green; if more acid be added, the colour becomes yellow. Syrup of violets, and tincture of turnsole, lose their colour by excluding from them carefully the air; but the re-admission of air, particularly of oxygen gas, restores to them their blue shades in all their former brightness. If the oxygen be allowed to act for a great length of time, the colour passes to a yellow.

The yellow or red decoctions of woods, when exposed to the air, are covered with pellicles, which pass successively through the shades of black, brown, purple brown, chestnut red, orange, and yellow. At this last shade the alteration stops, and the colour becomes unchangeable. These shades, enumerated in the order in which they usually take place, are owing to the absorption of quantities of oxygen, which goes on increasing till the colour passes from the deep brown to the yellow. They were all produced by introducing the oxygenated muriatic acid into a decoction of the bark of St. Domingo. The colouring matter precipitated in the yellow stage, was fixed, fusible in the fire, resinous, soluble in alcohol; whilst that in the red, or chestnut coloured stage, was soluble neither in boiling water nor in alcohol. From these and similar facts Fourcroy concludes, that oxygen enters into the composition of vegetable substances, and alters their colours.

2. That variations in the proportion of this principle, produces corresponding changes in the shades of the vegetable colouring substances.

3. That complete saturation with oxygen produces often yellow colours, which are the least alterable. And,

4. That the best means of obtaining fixed colours for painting would be, to choose colours which had been subjected to the action of the oxygenated muriatic acid.

Berthollet has since given an explanation of the effect of oxygen on the colouring matter of vegetables somewhat different from that of Fourcroy. He conceives, that the effect produced by oxygenated muriatic acid on colouring matters is similar to that of a slight combustion; that it is owing to the separation of the hydrogen, which, by combining with the oxygen, leaves the carbon predominant; so that the peculiar colour of the carbon is mixed in a greater or less degree with that which before existed.

This effect is very evident, when sugar, indigo, an infusion of nut-galls, or of fumach, is subjected to the action of oxygenated muriatic acid. The sugar and indigo acquire a dark colour, and exhibit unequivocal proofs of a slight combustion. The infusions of nut-galls and of fumach yield a black deposit, which is almost pure charcoal.

These phenomena are similar to those observed in the distillation of an organized substance; in proportion as the hydrogen is disengaged, in the form of oil, in the state of a gas, the substance becomes yellow, and is at last converted into a black charcoal. Whenever, therefore, according to this hypothesis, the oxygenated muriatic acid has rendered a vegetable colour yellow, fawn, or brown,

this effect has been produced by a slight combustion, in which a larger or smaller proportion of hydrogen has been converted into water; and the charcoal in this way becoming predominant, communicates to the substance its peculiar colour.

We have an example of these changes, in the effect of atmospheric oxygen, dew, and oxygenated muriatic acid, on the colouring parts of lint. These become soluble in the alkaline lixiviums, by an alternate exposure to the action of oxygen; but when these parts are precipitated from the alkali, collected, and dried, they are found to be of a black colour; so that the theory seems to be proved by the colour which they assume, and the quantity of charcoal which they afford, by analysis.

It is very probable, that in every case a part of the oxygen unites with the colouring parts, without combining in a particular manner with the hydrogen; and that it is in this way that the colouring particles of lint become, by the action of oxygen, more soluble in alkalis than they were formerly.

Sennebier remarked, that if a solution of the green matter of vegetables in alcohol be exposed to the solar light, it assumed an olive colour, and was in a few minutes entirely effaced. When the light was weak, the effect took place more slowly. In perfect darkness, the colour remains without alteration, or is at least altered very slowly. If the green colour was but slightly changed, it could be restored by the addition of an alkali; but when complete discolouration had taken place, the alkali produced no change. The green solution underwent no change in azotic gas, nor in a vessel that was completely full.

By exposing a vessel half filled with this solution over mercury, Berthollet found, after some time, that the mercury had risen in the flask, and that oxygen gas had been absorbed. The liquor, which was of a clear yellow colour, afforded a residue which was black, and of a carbonaceous nature.

This chemist placed vessels containing tincture of turnsole inverted over mercury with oxygen gas, in the light of the sun, and in a dark place. The tincture placed in the dark, after a long time, had undergone no change, and no oxygen gas was absorbed; while the tincture placed in the light had lost much of its colour, had become red, and the oxygen gas was in a great measure absorbed. A small quantity of carbonic acid was formed, to which the red colour of the tincture was to be attributed. See *Elements de l'Art de Teindre*, Tom. I. p. 44.

Dr. Bancroft objects to this explanation of Berthollet's, that it seems improper to apply the term Combustion to alterations which result from a simple addition of oxygen to colouring matters, without a separation or destruction of their component parts; though a great many of the decays and extinctions of these colours evidently arise from simple additions of oxygen. Besides, there are few vegetable colours which the muriatic acid does not injure as much as either the nitric or sulphuric acids; and therefore, when the muriatic acid changes or destroys the colours in question, it changes or destroys the affinities on which they depend, by producing effects different from those of combustion. Some vegetable colours are liable to be impaired, not so much by an accession of oxygen, as by the loss of it. The blue colour of indigo, for instance, absolutely depends upon a certain portion of oxygen; for a solution of this substance, by losing its oxygen, becomes pellucid and colourless, and afterwards speedily returns, through all the shades of yellow and green, to its original deep blue, by exposure to the atmosphere or to oxygen gas. This happens also to the solution of archil, orchella, and to the infusion of turnsole, and syrup of violets, which lose their colours by being secluded from the air, and regain them by being placed in contact with it. See *Experimental Researches*, &c. Chap. V.

CHAPTER XIX.

CONCERNING THE ANALYSIS OF PLANTS BY A NAKED FIRE.

AFTER having examined all the substances which may be obtained from plants, by simple methods, which are incapable of changing them ; and after having considered these matters as the immediate principles of organized substances, it is necessary to attend to the alterations they suffer when exposed to heat.

The ancient chemists were acquainted with no other method of analysing vegetables, and all their researches into the nature of these bodies, consisted in determining how much spirit, oil, and volatile salt they afforded by distillation. This method is at present no longer esteemed, as it is known, that most plants afford nearly the same products ; and the distillation of a great number of different vegetables, made by chemists, in other respects deserving the esteem of the public, has only served to undeceive us. In fact, how can it be imagined, that the action of fire, exerted on all the different principles in a vegetable substance, such as extract, mucilage, oil, resin, salt, gluten, &c. which decomposes each of these principles in a peculiar manner, can afford any knowledge respecting their nature and quantity ; more especially when it is observed, that the products of these several decompositions unite together, and produce new substances, such as did not exist in the vegetable under examination ? The analysis of vegetables, by distillation, is therefore complex and fallacious.

However, as none of the methods which art is in possession of, ought to be neglected in the chemical examination of any substance, we may have occasional recourse to this analysis, always carefully observing, that it is not too much to be depended on. It sometimes happens, that when the effects of aqueous, spirituous, and oily menstrua, on any substance, are compared with the alterations produced in it by fire, these last confirm the deductions made from the action of the solvents, and by the products of the distillation, indicate the substances

contained in greater or less quantities, the nature of its salts, &c. But to make valuable deductions from the analysis by fire, it is necessary, 1. To be well acquainted with the action of fire on each immediate or proximate principle, such as extract, mucilage, saline matter, oily juices, the fluid, or solid part, &c. 2. To compare the products, afforded by distillation, of the whole vegetable, with those usually afforded by the proximate principles, treated in the same manner. 3. To analyze the vegetable by menstruums, in order to obtain its proximate principles, and to make useful inductions from the alterations it has sustained by fire.

The process of distilling vegetables by a naked fire, is very easy and simple. A given quantity of a dry vegetable is put into a glass or earthen retort, so as to fill it not more than half or two thirds; the retort is then placed in a reverberatory furnace, and a receiver of a proper size adapted. It was formerly supposed necessary to use a receiver, perforated with a small hole, to give vent to the air said to be disengaged from vegetables, and tending to burst the vessels. But it is at present known, that the aeriform fluid which escapes from these bodies during distillation, is scarcely ever air, but consists of carbonic acid and hydrogen gas, holding carbon in a state of solution. Now, as these elastic fluids are products of the vegetable compound by fire, as well as the phlegm, the oils, and the volatile salts, it is equally necessary to collect them. For this purpose, a perforated receiver, communicating with an inverted glass vessel, filled with water or mercury, may be used. By this means, the liquid products are collected in the receiver, and the aeriform products under glass vessels, placed on the shelf of a pneumato-chemical apparatus. When the substance distilled affords a concrete salt, an adapter, or long glass vessel, is fixed between the retort and the receiver, in order that the sublimation may be made on its internal surface. The operation is begun, by placing a few pieces of lighted charcoal beneath the retort, and the fire is gradually increased till the vessel is red hot, and nothing more comes over. After the whole has become cold, the apparatus is unluted, to examine each of the products obtained.

Though the distillation of vegetables never affords products

which may be considered as principles of the plant, yet these products differ considerably from each other, and require to be carefully distinguished.

The first product which comes over, is an aqueous liquor, containing certain odorous and saline principles. As the distillation advances, the colour and saline properties of this phlegm become stronger. It is succeeded by an oil, whose colour, consistence, and weight, gradually increase. From some vegetables, a light and fluid oil is obtained; but from others, a ponderous oil, capable of becoming concrete. The smell of this oil is always strong and empyreumatic. During the time it comes over, a quantity of elastic fluid is disengaged, which consists either of the carbonic acid, or hydrogen gas, but most commonly of a mixture of both, holding in solution a greater or less quantity of carbon. At this period it is that the ammoniacal carbonat sublimes, when the vegetable is of such a nature as to afford it. When all these substances are past, the residue of the vegetable is of the nature of coal. We shall now proceed to examine more particularly into the nature and origin of each of these products.

The phlegm, according to the ancient chemists, is produced from the water that enters into the composition of the vegetable, and partly from the water of vegetation, especially when the matter is not entirely dry; so that its quantity is greater or less on this account. Most modern chemists think, that the water obtained in the distillation of vegetables, is formed by the union of the hydrogen and oxygen contained in these bodies. The phlegm is coloured red, by a small quantity of oily matter which rises, and is usually rendered saponaceous by the salt contained in the fluid. The saline matter is most commonly acid; for which reason the phlegm usually reddens the syrup of violets, and causes an effervescence with alkaline carbonats. This acid arises from the mucilage and the oil. But the phlegm is sometimes alkaline, as happens when nitrous or cruciferous plants, or emulsive and farinaceous seeds, are distilled; and it is often ammoniacal, because the ammoniac succeeds the acid, and combines with it. This fact may be ascertained by the addition of a small quantity of quicklime, or alkali, by which a strong smell of ammoniac will be produced, when ammoniacal salt is present.

The oils obtained from vegetables in this method, are all strong-smelling, highly-coloured, and possess nearly the same properties. Those parts of vegetables which contain a large quantity of these inflammable fluids, such as the emulsive seeds, afford a large quantity of oil in their analysis. Odoriferous plants afford an oil, which, at the beginning, slightly partakes of their peculiar smell, but quickly assumes the characters of other oils of this kind, namely, colour, weight, and an empyreumatic smell. All these fluids are very inflammable; the nitrous acid sets them on fire, and they are soluble in alcohol. They may all, by rectification, be rendered very fluid, light, and colourless, soluble in alcohol, and be converted into the state of etherial or volatile oils. These empyreumatic oils are formed by the action of fire, and did not exist in the vegetable.

The volatile salt, or ammoniacal carbonat, is only obtained from certain vegetables; but it is not true, as some chemists have affirmed, that it is afforded only by the cruciferous plants. All plants in general, which contain a certain quantity of glutinous, or vegeto-animal matter, afford more or less of ammoniac, by virtue of the azot, shown by Berthollet to exist in this vegetable principle. It is very seldom, however, that any considerable quantity is obtained in the concrete state, as it is usually dissolved in the last portions of the phlegm. This salt is produced by the union of the azot with the hydrogen of the oil, and for this reason it most commonly passes over towards the end of the distillation. It even seems, that the part which rises with the phlegm in the analysis of certain plants, such as the cruciferous plants, poppy, rue, &c. is always the product of a new combination; since Rouelle the younger has shown, that the plants themselves do not contain it in their natural state.

The elastic fluids disengaged during the distillation of vegetables, appear to depend on the nature of the vegetable. A plant which contains a large quantity of oily combustible fluid, affords a large quantity of hydrogen gas. Mucilages, on the contrary, afford carbonic acid. We have observed, at the article of the oxalic acid, that Bergman and Fontana obtained a large quantity of carbonic acid from that substance, and that

the latter chemist thinks, that vegetable acids are for the most part composed of it. It is not, therefore, to be wondered, that mucilages, in which Bergman discovered the same acid radical as exists in sugar, should afford, by analysis, carbonic acid. Lastly, There are some vegetable matters which afford azotic gas. These aeriform fluids are not extracted till near the end of the distillation, when the vegetable becomes entirely decomposed. Hales, who was not acquainted with their nature, observed, that the quantity of air disengaged during the distillation of vegetables is greater, the more solid they are; whence he concluded, that this element was the cementing principle and cause of solidity in bodies. It is easy to form a proper opinion of this hypothesis, from what has been already said.

CHAPTER XX.

OF CHARCOAL.

CHARCOAL is the black residue of vegetables which have suffered a complete decomposition of their volatile principles in closed vessels. The property of affording charcoal is only observed in such organic substances as contain the combustible matter called *oil*. The formation of coal was formerly attributed exclusively to the decomposition of this last substance; but we begin to perceive, that the carbonaceous matter exists, ready formed, in vegetables, and that the action of fire merely separates the volatile principles.

Charcoal in general is black, brittle, sonorous, and light; it retains the form of the vegetable, provided its texture has been consistent, and the quantity of fluid not very great. If, on the contrary, a soft and succulent plant be decomposed, the volatile matters, during their disengagement, destroy the organic texture, and afford a friable coal, which does not possess the figure of the vegetable. The quantities of coal vary according to the solidity and texture of the vegetable. Wood affords more than herbs; gums more than resins; and these last more than fluid oils. Each vegetable substance appears to contain it

in different quantities, if we consider charcoal as one of the immediate principles of this kingdom.

Charcoal is a substance which possesses very singular properties, for the most part little known. Though it is of the greatest importance in chemistry, and exhibits phenomena of the most singular kind, no chemist has yet attempted to discover its nature by a connected series of inquiries. Stahl, who attended more particularly to this substance than any other chemist, considers it as the principal repository of phlogiston. The knowledge we possess concerning the properties of charcoal is almost entirely confined to its economical uses; and the labours of philosophers exhibit nothing which can be called complete respecting it. The physical properties of charcoal differ according to the state and nature of the vegetable used in its formation; it is sometimes hard, and, as we have observed, retains part of the organization of the vegetable: other specimens are friable and pulverulent. Pure oils afford a coal in very fine particles, known by the name of lamp-black. Its weight varies according to circumstances. When well made, it has neither taste nor smell in any sensible degree. Its colour is also subject to variation, and is of a black more or less deep, either shining or dull. But the most important inquiry respecting this product of fire relates to its chemical principles.

Charcoal, exposed to the most violent heat in closed vessels, is not in the least altered. Heated in the pneumato-chemical apparatus, it does not afford hydrogen gas, unless water be present. A strong fire reduces it into vapour. When heated with contact of air, it burns, and is reduced to ashes, but with peculiar phenomena, which it is essentially necessary to distinguish carefully from those of other combustible matters. When set on fire, it becomes red, and burns with a white flame, which is more considerable, the larger the mass. It emits no kind of smoke, but is converted into the elastic fluid, carbonic acid, which, according to Lavoisier, is a combination of the carbonaceous principle and oxygen, the latter forming three-fourths of the whole. In this manner the charcoal becomes gradually consumed, and leaves only ashes, more or less white, and partly earthy. The different charcoals vary in their inflammability; a distinction which more particularly ascertains their uti-

lity in the arts. Some burn with flame, and are very quickly consumed; others do not take fire but with difficulty, burn slowly, and are not reduced to ashes but after a long ignition. There are some, as, for example, the charcoal of oils, which do not burn but with the greatest difficulty. This character seems to depend on the adherence of the carbonaceous principle to the fixed salts of vegetables; and as the proportion of these varies in each vegetable, the density of the charcoal, and the quantity of residue it leaves after combustion, depend on this cause.

As every charcoal contains more or less fixed salts and earth, we distinguish the pure matter of charcoal, supposed to be separated from the earthy matter, by the name *carbon*. It is the carbon only which combines with oxygen, and forms carbonic acid. It is therefore the radical of that acid.

Charcoal, exposed to the air, attracts humidity, probably because it is very porous, and perhaps likewise by virtue of the salts it contains, though they be not in a disengaged state. When moistened, it affords hydrogen gas, by heat, which arises from the decomposition of the water; for when that fluid is passed in vapour through an earthen tube filled with red-hot charcoal, these two bodies are converted into hydrogen gas and aeriform carbonic acid. The residue is a small quantity of ashes. Rouëlle has observed that fixed alkali dissolves a considerable quantity of charcoal by fusion.

The sulphuric acid, strongly heated with charcoal in powder, is decomposed by that combustible substance, which has a stronger affinity than sulphur with the oxygen.

The nitric acid is much more rapidly decomposed by charcoal. Dr. Priestley observed that much nitrous gas is produced in this mixture. Macquer found that the nitric acid very sensibly effervesces with this body by the assistance of heat. Proust has succeeded in setting fire to charcoal by the addition of a nitrous acid, weighing one ounce four drachms and twenty-three grains, in a bottle which held an ounce of distilled water. The novelty and importance of his experiments are such, that I shall quote his own words, extracted from his observations on Pyrophori made without alum, &c. inserted in the *Journal de Médecine* for July 1778.

“ Coal from the extract of carthamus, reduced to powder,
“ and recently calcined, detonated very strongly with the ni-
“ trous acid, and the rapidity with which the mixture took
“ fire, threw up the powder in the form of a very beautiful
“ fire-work. I calcined very fine powder of common charcoal,
“ and the detonation succeeded very well.

“ I introduced about a drachm of the powder of charcoal
“ into a very dry glass retort; I then poured in about a drachm
“ of nitrous acid, which had no sooner reached the bottom of
“ the retort, than the detonation took place with the greatest
“ rapidity: a flame of more than four inches in length issued
“ out of the neck of the retort while I held it in my hand,
“ which carried with it the powder, and very deep-coloured
“ vapours of nitrous acid. These vapours condensed into a
“ green liquor, scarcely fuming: it consisted of the nitrous
“ acid, weakened by the water which entered into the combi-
“ nation of that which detonated first. I poured new nitrous
“ acid on the charcoal which remained in the retort, and con-
“ tinued the process till the whole was entirely destroyed by
“ successive inflammation.

“ I repeated this experiment with calcined lamp-black; the
“ events were the same: the retort was found to contain only
“ a small portion of ashes, sometimes semi-vitrified, and adhe-
“ ring to the bottom of the retort.

“ All charcoals in general attract a considerable quantity of
“ humidity. It appeared to me, that charcoal calcined in the
“ evening, and kept till the next morning, was no longer pro-
“ per for these experiments, because it became sensibly mois-
“ tened in that space of time. But the most singular circum-
“ stance is, that these experiments are capricious, and do not
“ always succeed, though with the same charcoal, the same
“ acid, and the same proportions. The following manipula-
“ tion appeared to me to ensure success. If the acid be poured
“ in the middle of the powder, it does not take fire; but if,
“ on the contrary, it be suffered to run down the side of the
“ capsule, or crucible, so as to occupy the lower place, the de-
“ tonation is made from that point; the powder rises and takes
“ fire by the nitrous acid. When nitrous acid is wanting, the

“detonation ceases of itself, and the surrounding charcoal remains black.”

The action of the other acids on charcoal is not known.

This substance, assisted by heat, decomposes all the sulphuric salts, and forms sulphures with different bases.

It causes nitre to detonate, which burns it, by means of the oxygen afforded from the salt by the action of the fire. A preparation is made for chemical and pharmaceutical purposes, called *nitre fixed by charcoal*. Two parts of nitre, and one of powdered charcoal, are mixed, and thrown into a red-hot crucible on the fire. A strong detonation ensues, after which a white mass remains, which attracts the humidity from the air, consisting of the fixed alkali of the nitre and of the charcoal united to the carbonic acid. By lixiviating this mixture, the water dissolves the fixed alkali, and leaves a substance supposed to be an earth.

Sulphure of potash dissolves charcoal very readily both by the dry and moist way, and even combines with it more readily than any other substance. This discovery is due to Rouelle.

Metals do not unite with charcoal, but their oxyds recover the metallic state when heated with this substance. We have seen, at the article of Metals, that this phenomenon may readily be accounted for, from the affinity of the oxygen with the carbonaceous principle.

The action of vegetable substances on charcoal has not been much examined. It is only known, that a mixture of this substance with fat oils renders them inflammable by the nitrous acid; a circumstance which confirms the theory of Rouelle respecting the inflammation of oils by this acid. Within these few years, it has been pretended that charcoal is very useful in bleaching and in purifying the vegetable liquors with which it is heated^a.

All the facts here related concerning the known properties of charcoal tend to prove, that this body is composed of combustible matter, salts, and earths.

The peculiar combustible matter which constitutes more than three-fourths of charcoal, or the carbonaceous principle properly so called, is as yet scarcely at all known. It appears, however, to have the strongest affinity with oxygen, which it

takes from almost every other body, and that in many particulars it resembles the native carbure of iron ^b.

The various uses of charcoal in the arts and in chemistry are well known.

NOTES ON CHAPTER XX.

CHARCOAL.

^a THE observations to which Fourcroy alludes, are those of Mr. Lowitz of Petersburg. This chemist recommends charcoal that has been properly burned, and finely powdered, as the best means of correcting the bad smell and taste of putrid water. He recommends it also to purify vegetable liquors from the oily, mucilaginous, resinous, and particularly the colouring parts which they contain. This effect of the charcoal seems to be merely mechanical, and not chemical; for as soon as the porous substance of the charcoal is filled with these oily and colouring particles, it ceases to act till they are separated from it, which may be done by means of heat. See *Crell's Annal.* 1786, B. I. f. 293. 1788, B. II. f. 36. 1793, B. I. f. 135.

^b Dr. Bancroft, in a note, page 48. of his *Philosophy of Permanent Colours*, remarks, "that Lavoisier, Berthollet, and other pneumatic chemists, seem to consider the black colour of charcoal as naturally belonging to the vegetable matter from which it is formed, and not as the result or effect of combustion. To me, however, charcoal seems to be a kind of vegetable oxyd, consisting of the carbonaceous basis united to a certain portion of oxygen, enough to render this basis black (as it occasions the blackness of manganese), but not enough to saturate and convert it into carbonic acid. Hard woods contain so great a portion of the basis of charcoal, that if it really existed therein with its black colour previous to combustion, it is impossible to conceive how they should ever appear white, yellow, red, &c. since, in dying, &c. we find, that laying other colours upon a black ground only increases the blackness. Neither do I think that this blackness is the only circumstance in which charcoal differs from its basis, or the state in which the vegetable part thereof existed previous to combustion. On the contrary, I am persuaded, that its oxydation gives it new and very remarkable properties. Fourcroy has informed us (See *Ann. de Chem.* V.), that the aqueous extracts of several colouring matters, by being left for a considerable time exposed to the air, acquired acid, combined with a considerable portion of oxygen, and thereby assumed new colours, and at the same time became themselves much more fixed and permanent than before; which seems to be the case (though in a greater degree), of the vegetable basis of indigo and that of charcoal. This last is indeed never converted into charcoal but by such a degree of heat as must necessarily occasion its combustion with oxygen, (which never can be wanting even in close vessels, because it exists in the air vessels and other parts of vegetables); and when this conversion is made, the charcoal is rendered infinitely more indestructible than any other vegetable matter, as it will resist the combined action of sun, air, mois-

ture, &c. for hundreds of years; and, indeed, it can hardly be destroyed but by such farther combustion as will change it into carbonic acid gas. This indestructibility, as well as the black colour of charcoal, seem, therefore, to result from the combination of oxygen with its basis. Were not this the case, and did it really exist with its black colour naturally in vegetables, why do we not find it remaining entire after the other parts of vegetables are separated or destroyed by fermentation, putrefaction? &c. and why does it dissolve and rot with them undistinguished, and contrary to what happens when it exists separately, and in the form of charcoal? and why, when in this form, will it not recombine with matters similar to those separated from it, and enter with them into fermentation, &c. as it surely ought to do if it had acquired no new property, and only been left in a distinct form by the simple abstraction of these matters?"

This conjecture with regard to the nature of charcoal, is now fully proved by the late interesting experiments of Morveau on the combustion of the diamond.

In these experiments, the solar heat was applied, by means of a great lens, to the diamond, placed in a small porcelain cup, and surrounded in a proper apparatus with oxygen gas.

In one experiment, after being exposed for twenty minutes to the lens, the diamond did not take fire. It appeared at first farinaceous, and afterwards sensibly blackened on its surface. When the focus was intercepted by an opaque body, the diamond did not appear to have undergone any alteration, except having acquired a yellowish shade, similar to that of clear amber.

In another experiment, a slight scintillation appeared, but the diamond did not continue its own combustion.

In a third experiment, in which a still more powerful lens was used, the diamond exhibited a black point at the angle directly struck by the solar rays. After this, it soon became completely black, and of a coaly appearance; the instant afterwards brilliant, and, as it were, boiling points were distinctly perceived on the black ground. The solar rays being intercepted for a minute, the diamond appeared of a transparent red colour; and afterwards, when a cloud obscured the sun, it appeared of a much clearer white than at the commencement of the operation. When the sun re-appeared in full brightness, the surface of the diamond assumed a metallic brilliancy. It was then sensibly diminished in its size, not more than 1-4th remaining. It was without any marked angles or edges, but still very white, and of a beautiful transparency.

This diamond was exposed a second time to the solar light, and after twenty minutes entirely consumed. During this exposure, the same appearances were observed. A solution of barytes introduced over the mercury, became immediately milky, while the volume of the gas was diminished. In this process, a greater quantity of carbonic acid was obtained than what would have been obtained, had the diamond been in the same state with common charcoal. Instead of the proportions of 0,28 of combustible substance, with 0,72 of the acidifying principle which obtain in the combustion of charcoal, the proportion in the combustion of the diamond was 17,88 of carbon, and 82,12 of oxygen.

This diamond, of which Morveau effected the complete combustion, was a native octohedral crystal, of 199,9 milligramms in weight. It consumed during combustion, 677 centimetre cubes of oxygen gas, and afforded 1117,96 milligramms of carbonic acid. Morveau has carefully summed up the results of his discovery in the following inferences,

1. It is not merely by its colour, weight, hardness, transparency, and other

sensible qualities, that the diamond differs from charcoal, as has hitherto been imagined.

2. Neither is it only by the state of aggregation in the matter which constitutes diamond.

3. Nor lastly, is this difference owing to the 200th part of residue which the charcoal affords, nor to the small quantity of hydrogen which it contains.

4. But the most essential distinction exists in the chemical properties.

5. The diamond is the purest combustible substance of this genus.

6. The product of its combustion, or of its combination with the oxygen to the point of saturation, is carbonic acid without residue.

7. Charcoal burns at a temperature which may be estimated at 188° of the centigrade thermometer. The diamond burns only in a temperature of about 90 pyrometrical degrees, which in the scale of Wedgwood constitutes a difference of from 188° to 1765° .

8. Charcoal set on fire maintains by itself in oxygen gas the temperature necessary for its combustion, but the combustion of the diamond ceases as soon as it is no longer maintained by the heat of the furnace, or by the concentration of the solar rays.

9. The diamond requires for its complete combustion a much greater quantity of oxygen than charcoal does, and produces also more carbonic acid; for 1 part of charcoal absorbs in combustion 2,527 of oxygen, and produces 3,575 of carbonic acid; but 1 part of the diamond absorbs somewhat more than 4 parts of oxygen, and produces 5 of carbonic acid.

10. There are substances which exist in an intermediate state of composition between diamond and charcoal; these are *plumbago*, or the native carbure of iron, the incombustible fossil coal, the carbure of alumine of Dolomieu, *anthracolite* of Werner, the black matter united to iron, in the state of cast iron and steel, coaly residues difficult of incineration, and charcoal itself unburned by the action of a strong heat, without the contact of air. The proper name for these substances is *oxydules of carbon*.

These substances mixed, or weakly combined with three or four hundred parts of their weight of iron or alumine, afford, by their combustion, carbonic acid like charcoal and the diamond.

They approach to charcoal in their colour, lightness, and opacity. Like that substance they decompose water, cement iron, disoxygenate metals, sulphur, phosphorus, arsenic, and, like charcoal, they conduct the electric fluid.

They approach to the nature of the diamond in containing much more combustible matter than charcoal, which is manifested by their absorbing more oxygen, and more carbonic acid, in their decomposing more nitrous acid, in their refusing to burn, even in fused nitre, unless at a very elevated temperature, and in their combustion ceasing when that temperature is diminished.

They appear to differ from each of these bodies, by their property of producing the galvanic irritation with zinc, as well as silver does; an effect which is not produced either with the diamond or with charcoal.

12. The diamond, therefore, is the purest carbon, the pure acidifiable basis of the carbonic acid.

Its combustion is effected at three periods, which require three different temperatures. At the first and least elevated temperature, the diamond assumes a black and leaden colour. This is the first degree of oxydation. It is the state of *plumbago*, and of the *anthracolite*.

At the second temperature, which may be estimated at 18 or 20 pyrometrical

degrees, there is a new, slow and successive, combination of oxygen. It is a progress of oxydation which constitutes the habitual state of charcoal, or rather that in which it is found, after the action of a strong heat in closed vessels has disengaged part of its oxygen.

Plumbago is therefore an oxyd of the first degree, or *oxydule*, charcoal an oxyd of the second, and carbonic acid the product of the complete oxygenation of carbon.

Supposing, therefore, that we could operate with sufficient precision to take from the surface of the diamond the black matter, in proportion as it formed, by withdrawing it suddenly each time from the action of the solar heat, we should undoubtedly convert it into charcoal, or at least into plumbago, if the too rapid transition of the last degree of oxydation to oxygenation should not permit us to obtain it in this state.

13. Lastly, From these principles flow many important consequences to chemistry and the arts.

After this conclusion it will no doubt be demanded, how it happens that the simple matter, the pure carbon, or diamond, is so scarce, while its compounds in different states are so abundantly dispersed? To dispel the astonishment of those who might consider this a ground of distrust, I shall remind them, that the aluminous earth is likewise one of the commonest substances, though the adamantine spar, no less rare than the diamond, is nevertheless alumine; that iron exists every where, under every form, excepting in the state of purity, for the existence of native iron is still doubtful. The wonder consists only in the opposition between facts and our opinions; it disappears in proportion as we discover and appropriate the powers of nature to produce the same effects. See *Ann. de Chim.* Tom. XXXI. p. 72.

CHAPTER XXI.

CONCERNING THE FIXED SALTS AND EARTHS OF VEGETABLES.

WHEN a vegetable coal has been burned, a grey, blackish, or white matter remains, according to the nature of the charcoal. This substance, called *ashes*, is very compounded; when well made, it contains only saline and earthy substances, mixed with iron, and a small quantity of manganese. When the charcoal has been burned with difficulty, the ashes still retain a small portion of inflammable matter. Lavoisier, on examining the wood ashes used by the saltpetre-makers, found them to contain extractive and resinous-extractive matters. The saline substances obtained, by lixiviation, from ashes, have been called the fixed salts of plants. The incineration of vegetables is used for obtaining three kinds of salts, which we shall here describe.

1. Potash, from which the vegetable fixed alkali is obtained, is prepared in the north, by burning wood, with which those countries abound. This salt is very impure; it often contains combustible matters, which diminish its whiteness, and frequently neutral salts, such as the sulphates of potash, of soda, and of lime, the muriates of potash and of soda, a small quantity of carbonate of soda, with the oxyd of iron and earthy substances. To purify this salt, and to extract the potash pure, it is dissolved in the smallest possible quantity of cold water. The fluid becomes charged with the alkali, and some of the neutral salts; and the earth, the charcoal, the iron, and the sulphate of lime, often contained in potash, are separated by the filter. This solution is then evaporated to a pellicle, and the several salts it contains are suffered to crystallize by cooling. After several filtrations, evaporations, and crystallizations, when the lixivium no longer affords any neutral salt, it is evaporated to dryness, and calcined. The salt is then carbonate of potash, mixed with the same alkali in a caustic state: it seems, however, always to contain some neutral salts, and a small quantity of earthy substance, which is deposited by

standing, and may be separated by the filter. After which, it may be used in the nicest chemical experiments.

2. Soda of commerce, is the residue of the combustion of plants that grow on the sea coasts. It is prepared at Alicant in Spain, in Languedoc, at Cherbourg, &c. by burning various species of plants. At Alicant, they use the kalis; and at Cherbourg, the algas, and fucus, commonly known by the name of varech. The first plant contains a much greater quantity of soda than the second, which affords scarcely any. These different plants are burned in a trench. At Cherbourg, when the combustion is advanced, and the ashes are very hot, they are strongly agitated, and kneaded together with large poles. By this motion, the substance, which is sufficiently hot to undergo a kind of semi-vitrification, takes the form of hard and solid lumps, known in commerce by the name of *salicore*, *salicote*, *lamarie*, and *alun catin*. The names, by which it is more particularly distinguished, denote either the plant from which it was obtained, or the country where it was made. The soda of Alicant, likewise called *barilla*, is the best for chemical purposes, and those arts which require much fixed alkali. The soda of Cherbourg, or of varech, contains less alkali, and ought not to be used in chemical experiments; but it is advantageously used in the manufacture of glass, because the vitreous frit it affords is found to be very serviceable in that manufacture.

The soda of commerce, chemically considered, is a compound of caustic soda, carbonat of soda, carbonat of potash in a small quantity, sulphat of potash and of soda, muriat of soda, charcoal, iron in the state of a prussiat, or of Prussian blue, according to the observation of Henckel, and earth, partly disengaged, and partly combined with fixed alkali, as in that of Cherbourg. To separate these substances, and obtain pure carbonat of soda, it is dissolved in cold distilled water, and filtered, to separate the earth, iron, and coaly matter; after which it is evaporated, as we have observed concerning potash. This alkali is purified more easily than that of potash, because, as it crystallizes more readily, it can be better separated from the portion of caustic soda; yet it contains some of the neutral salts, and Prussian blue, when first crystallized,

which must be separated by repeated solutions and crystallizations.

3. Fixed salts are prepared in pharmacy, which have been greatly recommended by Tachenius, and are still distinguished by his name. The process of this chemist consists in placing the plant, whose salt is proposed to be obtained, in an iron pot. This vessel is heated till its bottom is red hot; the plant, which is continually stirred, emits much smoke, and takes fire, at which time the pot is covered, so that the smoke may be dissipated, and the flame extinguished. By this means, the plant is gradually consumed. When reduced to a kind of blackish ashes, it is lixiviated with boiling water, which affords a yellowish, or brown salt, by evaporation to dryness. This salt is often alkaline, but is very impure; it is coloured by much extractive matter, which is mixed with all the neutral salts the plant contained. As it is a saponaceous compound, good effects often follow its use; but it cannot be supposed to possess the same virtues as the plant from which it was extracted, because its principles have necessarily been altered by the combustion. It would be of considerable use to examine, analytically, the different fixed salts of plants, prepared after the manner of Tachenius, in order to discover the saline and extractive matters they contain, and to determine their virtues, and the dose in which each ought to be administered.

4. When all the saline matter is washed off from the ashes of vegetables, the remainder is a pulverulent substance, more or less white, or coloured, insipid, insoluble in water, and hitherto considered as an earthy substance.

Iron may be extracted from this residuum by the magnet. This metal, as well as the manganese which vegetable ashes have lately been found to contain, existed, ready formed, in the vegetable. Many philosophers have supposed, that the colours of plants are produced by iron. Baumé, who, in his memoir concerning clays, has mentioned the earthy residue of vegetables, affirms, that it forms alum with the sulphuric acid, and likewise sulphat of lime, slightly differing from that which is produced by pure calcareous earth. Hence, Baumé thinks that the earth of vegetables consists of alumine, and an

earth resembling calcareous earth, though it sensibly differs from it, according to him, in not forming quicklime by the action of fire. He thinks, that the alumine is formed in these organized substances by the collision to which siliceous earth is exposed, and the action of acids with which it combines; that the alumine, once formed, passes to the state of calcareous earth, by successive elaborations in the tubes of vegetables.

We may here observe, that the discoveries made in Sweden, on the saline nature of bones, which appear to be the same with respect to animals as the fibrous parts are in vegetable substances, render it probable, that this residue is far from being merely an earth. An accurate analysis, such as has not hitherto been made, may show, that this supposed earthy substance is calcareous phosphat; at least we may suspect this to be the case, since the experiments of Margraaff and Berthollet, who have obtained phosphorus from mustard seed, from gluten, and from several other vegetable substances, and those of Hassenfratz, who has extracted phosphoric acid from many of the plants which grow in marshes.

CHAPTER XXII.

CONCERNING FERMENTATION IN GENERAL, AND THE VINOUS FERMENTATION IN PARTICULAR.

AFTER having considered vegetables in the state in which they naturally exist, we shall proceed to describe the changes they experience in different circumstances. These alterations, which entirely depend on their nature, are always the consequence of a phenomenon called *fermentation*.

Fermentation is a spontaneous commotion in a vegetable substance, by which its properties are totally changed. This commotion is peculiar to the fluids of organic matters; no other substances, except those which have been elaborated by the principle of vegetable or animal life, being susceptible of

it. Chemists have not sufficiently attended to this important truth, whose application to the phenomena which take place in organized bodies, cannot but be of the greatest use in medicine and in the arts.

There are several circumstances required in order that fermentation may proceed. Such are,

1. A certain degree of fluidity: dry substances, in fact, do not ferment at all.

2. A certain degree of heat. Each kind of fermentation requires a due degree of heat, but cold stops the progress of every ferment.

Chemists, after Boerhaave, have distinguished three kinds of fermentation: the vinous, which affords wines and alcohol; the acetous, which affords vinegar, or acetous acid; and the putrid fermentation, or putrefaction, which produces ammoniac. It must be observed, that there are many fermentatory processes which do not seem to belong to these three kinds; such, perhaps, are the fermentations of bread, of mucilages, that which develops the colouring parts, &c. It has been thought, that the fermentations always follow each other in the order we have mentioned; but there are bodies which become acid, without having previously undergone the vinous fermentation; and there are others which putrify without passing through the two first stages. We may likewise observe, that the intestine motion of maturation appears to constitute a kind of primitive fermentation, by which saccharine matter is developed.

The vinous fermentation, is that which produces wines and alcohol. It may be considered with respect to, 1. The conditions necessary to its production; 2. The phenomena which accompany it; 3. The several substances susceptible of this fermentation; 4. Its cause; and, 5. Its products.

Experience has shown, that all vegetable matters are not capable of passing to the vinous fermentation, but that the union of several peculiar circumstances is necessary for this purpose.

These conditions are, 1. A saccharine mucilage. This substance only is capable of passing to the vinous fermentation, and of forming wine.

2. A degree of fluidity, slightly viscid. If the vegetable fluid be either too thick, or too thin, it will not ferment.

3. A degree of heat, from twelve to fifteen degrees of Reaumur's thermometer, or between fifty-five and sixty-five of Fahrenheit.

4. A large mass, in which a rapid commotion may be excited.

When these four conditions are united, the vinous fermentation takes place, and is known by the following characteristic phenomena.

1. An intestine motion is excited in the liquor, which increases till the fermentation is well established.

2. The bulk of the mixture is quickly augmented, and this augmentation follows the progress of the intestine motion.

3. The transparency of the fluid is diminished by opaque filaments, which are agitated, and carried to every part of the fluid.

5. A degree of heat is produced, equal to eighteen degrees (seventy-two and a half Fahrenheit), according to the Abbé Rozier.

5. The solid parts, mixed with the liquor, rise and float, in consequence of the disengagement of an elastic fluid.

6. A large quantity of carbonic acid gas is disengaged. This gas forms a stratum in the upper part of the fermenting vats, which may be easily distinguished from air. In this stratum it was, that Dr. Priestley and Duc de Chaulnes made their valuable experiments. Candles, plunged in this stratum, are extinguished, and animals die therein; lime water is precipitated, and caustic alkalis crystallize perfectly. This acid, contained in the fermenting vats of brewhouses, frequently produces the most fatal effects on the workmen.

7. The disengagement of this gas is accompanied with the formation of a great number of bubbles in the viscid liquor, through which the carbonic acid must pass.

All these phenomena gradually cease, in proportion as the liquor loses its sweet and mild taste, and becomes brisk, penetrating, and capable of producing intoxication.

Necessity has induced mankind to prepare fermented liquids with a great number of different vegetable substances; but ex-

perience has shown, that saccharine matters alone are capable of forming this kind of fluid. The following being most commonly used, require to be enumerated.

1. The juice of grapes produces wine, properly so called: it is the best of all fermented liquors. The art of cultivating vines, which is of great importance, requires an attention to the following objects. 1. The nature of the soil. It is known, that a dry soil is in general well adapted to this plant, and that a strong soil does not agree with it. 2. The cultivation of this vegetable. It is pruned; its branches are bent, to impede the course of the sap; care is taken that it be exposed to the heat of the sun, and more especially to the heat reflected from the earth, &c. It is not manured, &c. 3. The history of its vegetation, its exposition, its flowering, the formation and ripening of the grape. 4. The accidents to which it is exposed, such as frost, heavy rain, moisture, &c. 5. The time of vintage, which should be dry and hot. These preliminary circumstances being known, the art of making wine is to be considered, which consists in putting the stalked grapes into a vessel, exposed to a heat of fifteen or sixteen degrees, to break, agitate, and turn them over. When the fermentation is excited, and all its phenomena take place, the juice of grapes, or must, should be neither too fluid, nor too thick; in the first case, it requires to be thickened by boiling; in the latter it is diluted with water. When the wine is made, it is drawn off into casks, which are left open, where it experiences a second insensible fermentation, by which its principles are more intimately combined; a fine lye, and a salt, known by the name of tartar, being precipitated. To preserve the wine, rags dipped in sulphur, are burned in the cask which contains it.

The knowledge of the different kinds of wine is an object of considerable importance. France produces a great number of excellent wines. Those of Burgundy are preferable to any other for constant use, because their principles are perfectly combined, and no one predominates over the other. The wines of the province of Orleans resemble those of Burgundy, when they have been matured by keeping, which combines the excess of alcohol they contain with their other principles. The red wines of Champagne are excellent, and of a delicate fla-

vour. The white wine of this province, which does not sparkle, is to be preferred to the sparkling wine, whose penetrating and subacid taste, as well as its property of sparkling, depend on the carbonic acid contained in it, when bottled before the fermentation was finished. The wines of Languedoc and Guienne are of a deep colour, and are excellent bracers and stomachics, especially when of a good old age. The wines of Anjou are white, very spirituous, and intoxicate quickly.

As to foreign wines, those of Germany, known by the name of Rhenish and Moselle, are white, and very spirituous; their taste is keen and penetrating, and they quickly produce intoxication. Some wines of Italy, such as those of Orvieto, Vicenza, the Lachryma Christi, &c. are well fermented, and resemble the good wines of France. Those of Spain and of Greece are in general sweet, crude, imperfectly fermented, and very unwholesome. We must, however, except those of Rota and Alicante, which are with justice esteemed to be stomachic and cordial.

2. Apples and pears afford cyder and perry. This species of wine is very good, and affords good brandy, as M. d'Arcet has shown.

3. Cherries afford a tolerable good wine, from which a kind of brandy is distilled, called Kirchenwasser by the Germans.

4. Apricots, peaches, and plumbs, afford a wine of inferior quality.

5. Impure sugar, dissolved in water, ferments readily: from this kind of wine, a spirit, called rum, taffia, guildive, &c. is made.

6. The seeds of gramineous plants, and especially barley, afford a species of wine, called beer. The art of brewing consists in the following processes. Barley is steeped in water for thirty or forty hours, after which it is laid in a heap, to sprout or germinate; it is then dried in a kiln, and the buds separated by sifting; after which it is coarsely ground, and is distinguished by the name of *malt*. A certain quantity of malt is put into a vessel, called the mash-tun, on which water, nearly boiling hot, is poured, which dissolves the mucilage. This being drawn off, a second quantity of heated water is poured on the malt, and in like manner drawn off. This fluid, called

called *wort*, is boiled up with hops, and is put, together with yeast, into a vessel, called the *cooler*. When the fermentation begins to subside, the beer is stirred up, and drawn off into casks; the second fermentation throws up a scum, called yeast, which serves to excite fermentation in future brewings. The germination develops a saccharine matter in the barley, to which it owes its property of forming wine: the same process succeeds with most other gramineous seeds.

The whole of these facts prove, that the saccharine matter is the only principle of vegetables capable of passing to the vinous fermentation, and that water is necessary for the production of this intestine motion. Modern chemists think, that the vinous fermentation consists only in a change in the proportion of the principles of the sugar. A great part of its oxygen seizes the carbonaceous matter of the sugar, and forms carbonic acid, which is disengaged during this fermentation; while the hydrogen, united with a small portion of the carbon, constitutes wine, and is capable of forming a very light combustible subtle body, containing much less carbon than the sugar, and much more inflammable: this is alcohol.

The product of all these fermenting substances, is a liquor more or less coloured, of an aromatic smell, a penetrating and hot taste, which, in small doses, assists the action of weak fibres, but produces intoxication when taken too largely. It is universally known by the name of *wine*.

The wine of grapes, for example, is composed of a large quantity of water, an aroma peculiar to each wine, of a principle approaching to alcohol, an essential salt called *tartar*, and an extracto resinous colouring matter, which produces the colour in red wines.

Before we proceed to describe the methods of separating these principles, it will be proper to describe the uses and properties of the fluid itself. Wine dissolves many substances, by virtue of the water, the alcohol, and the essential acid salt, of which it is formed. It unites with extracts, resins, certain metals, &c. On these properties depend the preparations of medicinal wines, such as, 1. Emetic wine, prepared by macerating four ounces of crocus metallorum in two pounds of good white wine; the liquid is filtered, or is used without

filtration, in paralytic or apoplectic cases. 2. Chalybeat wine, made by digesting one ounce of steel filings with two pounds of white wine: it is an excellent tonic and aperitive medicine. 3. The wines of vegetables, prepared (a) either with red wine, in which astringent or aromatic plants are macerated; (b) or with white wine, which is usually employed with antiscorbutic plants; (c) or with Spanish wine: the wine of Squills, and also the liquid laudanum of Sydenham, are prepared with this wine. The latter is made by digesting for several days two ounces of sliced opium, one ounce of saffron, a drachm of powdered cinnamon and cloves, in a pound of Spanish wine. This medicine is a very good sedative, taken in the dose of a few drops, especially in cases in which it is feared that opium may weaken the patient, or stop some useful evacuation.

The action of fire is commonly used to decompose wine, and separate it into its several principles. The distillation is performed in an alembic of tinned copper, to which a receiver is adapted; as soon as the wine boils, a colourless fluid, slightly opaque, and milky, of a hot and penetrating taste, and a strong agreeable smell, comes over. This fluid is received till the vapours no longer take fire by a candle. It is called *brandy*, and consists of water, alcohol, and a small portion of oil, which renders it milky at first, and after a certain time colours it yellow. The colour of old brandy in commerce does not, however, arise from the oil alone, which comes over in the distillation, but likewise from the extractive matter it takes from the cask in which it is contained. Brandy is the fluid from which alcohol is extracted, as we shall hereafter see. The residual liquor, after it has afforded brandy, is of an acid austere taste, turbid, and deposits a large quantity of saline crystals, which appear to be tartar. The wine is therefore entirely decomposed, and cannot be restored to its former properties by combining the spirituous product with the residue. Hence the analysis appears to be complicated. If the residue of wine which has afforded brandy be evaporated, it takes the form and consistence of an extract. The colouring part may be separated by the addition of alcohol, which does not act on the tartar. Water does not precipitate this tincture. By evaporation of

the tincture to dryness, a residue is obtained, which quickly takes fire, and is soluble in water; it is a true refinio-extractive substance, which the alcohol, formed by fermentation, has extracted from the skins of the grapes. From this analysis it appears that wine consists of water, the principles of alcohol, tartar, colouring matter, and of an aroma, which is destroyed or modified by the action of fire. We have already explained the nature and properties of these substances; alcohol only remains therefore to be treated of.

Before we proceed to speak of this product, we shall take notice of a substance that precipitates from wine during its fermentation, and is called *lees*. It consists of the seeds and skins of grapes, impure tartar, and sulphat of potash. By distillation with a naked fire, it affords brandy: treated in a retort, it affords acid phlegm, oil, ammoniac; and its coal contains carbonat and sulphat of potash. The incineration of the lees of wine in the open air affords a caustic potash, mixed with carbonat and sulphat of potash, and known in commerce by the name of *cendres gravelées*. Several chemists have been of opinion, that in this analysis of wine the alcohol was separated only by the action of fire. But if this substance were ready formed in the wine, it would be obtained by a gentle heat, whilst a boiling heat is necessary. Thus modern chemists think alcohol is formed by the heat of ebullition; that its principles, namely, a large proportion of hydrogen, and a small quantity of carbon, combine together during the distillation of wine; in short, that this liquor contains only the principles of alcohol.

NOTES ON CHAPTER XXII.

^a FOURCROY takes no notice of *ferments*, though their effects in promoting fermentation be universally known. The nature of their action indeed is but imperfectly, if at all, understood. They are said to be substances in which fermentation has already begun, or which are very much disposed to enter into that process. Some curious experiments made by Mr. Henry, and related in the second volume of the *Manchester Memoirs* seemed to prove, that the action of ferments

consists in producing a disengagement of carbonic acid gas. This chemist discovered, that the fermentation of mucilaginous and saccharine fluids could be greatly accelerated, by impregnating them with that acid. The reader will find some farther remarks on the preparation and use of artificial ferments in a paper by Mr. Collier, inserted in the first part of the fifth volume of the *Manchester Memoirs*. It is unnecessary to take any notice in this place of the opinion of Fabroni, viz. that the substance which reacts on the sugar in fermentation is the vegeto-animal, or glutinous part of vegetables; for the opinion, however ingenious, is yet, as Fourcroy very justly remarks, totally unsupported by experiment. See *Ann. de Chem.* Tom. XXXI. p. 312.

CHAPTER XXIII.

THE PRODUCT OF THE VINOUS FERMENTATION, OR ALCOHOL.

WE have seen that brandy, obtained by distilling wine with a naked fire, is a compound of alcohol, water, and a small portion of oil. Distillation is used to separate these substances, and to obtain alcohol in a state of purity ^a. There are several methods of distilling alcohol. Baumé advises to distil brandy a considerable number of times, by a water-bath, to obtain all its spirit. He recommends the separation of the first fourth part of the product of the first distillation, and likewise of the first half of the product of the following distillations, to mix all these together, and to rectify by a gentle heat. The first half of the fluid which passes in this rectification is the purest and strongest alcohol; the remainder is less strong, but very good for ordinary purposes. Rouelle directs, that half the brandy made use of be drawn off by distillation on the water-bath; this first product is common alcohol, which being rectified twice, and reduced to about two-thirds, becomes a stronger spirit. This is to be again distilled with water, according to the process of Kunckel, which separates the oil; the distilled spirit being again rectified, may be depended on as perfectly pure. The residue of brandy, after distillation, is water, containing colouring matter, on the top of which a peculiar oil floats.

Hence it may be observed, that the purity and strength of alcohol must differ according to the processes used in obtaining it. A method of discovering its purity has long been sought after. It was formerly supposed that alcohol, which readily catches fire, and leaves no residue, is very pure; but it is at present well known, that the heat excited by its combustion is sufficiently strong to dissipate all the phlegm it might contain. Another proof has been proposed, by means of gunpowder: when alcohol, set on fire in a spoon upon gunpowder, does not inflame it, it is considered as bad; if, on the contrary, it sets it on fire, it is judged to be excellent. But this proof is very fallacious; for when a large quantity of the best alcohol is

burned on a small quantity of gunpowder, the water it affords during its combustion moistens the powder, and prevents its taking fire; whereas it may be inflamed by burning a very small quantity of phlegmatic alcohol on its surface. This method is therefore no more to be depended on than the former. Boerhaave has described a very good process for ascertaining the purity of this fluid: it consists in throwing the very dry powder of carbonat of potash into alcohol; this unites with the superfluous water of the alcohol, and forms a more ponderous and coloured fluid than the alcohol, with which it does not mix, but falls to the bottom. Lastly, Baumé, on the consideration that alcohol is lighter the purer it is, has contrived an areometer, by which the degree of purity of this fluid, and of all volatile liquors, may be accurately ascertained. When the instrument is plunged in alcohol, it sinks deeper, in proportion as the fluid is purer. By experiments carefully made, he has determined that the purest and most highly rectified alcohol gives thirty-nine degrees of his areometer, at 10° of Reaumur's scale. The method of constructing this instrument, as well as the results afforded by different quantities of alcohol, may be seen in his *Elements of Pharmacy*, and may be applied to determine the strength of alcohol by the hydrometer*.

* Notwithstanding the labours of many ingenious chemists, and particularly those of Mr. Bories, related in his *Memoir*, which obtained the prize proposed by the states of Languedoc in 1772, and published at Montpellier in the year 1774, much remains to be done before the strength of spirits can be determined with sufficient accuracy even for commercial purposes. If ardent spirit, which is so highly dephlegmated as not to liquify hot pulverized alkali, be considered as pure spirit, or the standard extreme, distilled water forming the other extreme, it will then be necessary to ascertain by experiment, 1. The specific gravity of a certain number of mixtures of water and this spirit, taken so near each other, as that the intermediate specific gravities may not sensibly differ from those deduced mathematically in the usual manner. 2. The expansions or variations of specific gravity of these mixtures at the different temperatures of the atmosphere. 3. The change of specific gravity produced by the solution of saccharine or oleaginous substances in these spirits. 4. Easy methods must be devised to show the presence and quantity of the last mentioned substances; and also, 5. To determine the specific gravity of the fluid.

These requisites demand a great number of accurate experiments to be made. Rectified ardent spirit, repeatedly affused on dry alkali, till it would no longer dissolve or liquify it, was found by Mr. Bories, by many experiments, to have the following specific gravity:

Pure alcohol, obtained by the process we have described, is transparent, exceedingly fluid, and so light, that it weighs four hundred and eighty grains, in a bottle which contains five hundred and seventy-six grains of distilled water. Its smell is penetrating and agreeable; its taste is hot and strong. It is extremely volatile, rising and passing over in close vessels, by a very gentle heat, and is by this means separated from the small quantity of water it might contain. The first portions are the most volatile and pure. It was formerly thought that a large quantity of air was always disengaged during the distillation of alcohol. This supposed air is now known to be the most volatile part of the spirit, which passes over in the form of gas.

When alcohol is heated with the contact of air, it soon takes fire, and exhibits a light flame, white in the middle, and blue at the sides; it completely burns away, when pure. Many chemists have attempted to discover the product afforded by alcohol in burning. They found that its flame is accompanied with neither foot nor smoke; and that the volatilized matters when condensed, are pure water, without taste or smell, absolutely in the state of distilled water. Boerhaave, from this phenomenon, supposed that the flame is produced by the water; and this opinion is confirmed by the knowledge we at present possess, respecting hydrogen gas obtained by the de-

$$\begin{aligned}\text{Reaumur's Therm.} + 10^{\circ} &= 820\frac{2900}{3055} \\ &+ 15^{\circ} = 817\frac{65}{3055} \\ &+ 20^{\circ} = 813\frac{2285}{3055}\end{aligned}$$

The specific gravities of mixtures, by measure, of the foregoing spirit with distilled water, were as under:

Temperature + 15° Reaumur.				
Spirit	10	Water	0	Specific gravity
	9	-	1	817 $\frac{65}{3055}$
	8	-	2	844 $\frac{3580}{3055}$
	7	-	3	869 $\frac{4705}{3055}$
	6	-	4	893 $\frac{1895}{3055}$
	5	-	5	915 $\frac{925}{3055}$
				934 $\frac{3630}{3055}$

composition of water, and the water obtained by burning hydrogen gas with oxygen gas. Lavoifier discovered, that when alcohol is burned in a chimney adapted to receive the vapours, a larger quantity of water is obtained than the whole of the spirit made use of amounts to; whence it follows, that this liquor contains a large quantity of hydrogen. On the other hand, Berthollet has remarked, that when a mixture of this spirit and water is burned, the residual fluid precipitates lime water. This experiment shows, that alcohol contains a small quantity of carbon, which, by its combustion or combination with oxygen forms the carbonic acid. Chemists have adopted different opinions respecting alcohol; Stahl, Boerhaave, and some others, have considered this fluid as a compound of a very attenuated oil, a subtle acid, and water. It is therefore, according to this opinion, a kind of acid soap. Others, at the head of whom may be placed Cartheuser and Macquer, think that alcohol is formed by the union of phlogiston and water. The nature of this fluid is not yet well known, but it is considered as a compound, consisting of a large proportion of hydrogen, with a small quantity of carbon.

Alcohol exposed to the air, evaporates at a temperature of 55° , and leaves no residue, except a small quantity of water, when it has not been well dephlegmated. This evaporation in the air is more rapid, the hotter the atmosphere; and produces a degree of cold, which is stronger in proportion to its rapidity. Alcohol has the form of an elastic fluid at 185 degrees of Fahrenheit's thermometer.

Spirit 4	Water 6	Specific gravity	$951\frac{3695}{8055}$
3	- - 7	- - -	$965\frac{1925}{5055}$
2	- - 8	- - -	$976\frac{1320}{5055}$
1	- - 9	- - -	$987\frac{715}{5055}$
0	- - 10	- - -	1.000

I find, by distilling 20 measures of the best spirit of wine of the shops, (Sp. Gr. = 836) in glass vessels, by a lamp, that the first measure which came over had a specific gravity of 820, at a temperature of 71° of Fahrenheit, or about $+ 17$ 1-half of Reaumur. This, which is the strongest spirit mere distillation can afford, contains about one part in the hundred of water, of which it may be deprived by alkali. *Note of the Translator.*

Alcohol unites with water in all proportions, and is perfectly soluble in that fluid. This solution is attended with heat, and produces spirits, whose strengths are greater in proportion as the quantity of alcohol is greater. The affinity of combination between these two fluids is so strong, that water is capable of separating alcohol from many bodies with which it may be combined; and on the contrary, alcohol decomposes most saline solutions, and precipitates the salts. From the consideration of this last property, it is, that Boulduc proposes the use of alcohol to precipitate the salts contained in mineral waters, and to obtain them unaltered.

Alcohol has no action on pure earths. It is not known whether it is altered by barytes and magnesia. Lime appears capable of producing some change in this fluid, since it acquires a degree of smell when distilled from that saline earthy substance. But this alteration has not been properly inquired into.

Caustic fixed alkalis appear really to decompose alcohol, as is known by the medical preparation called the *acid tincture of tartar*. To prepare this, potash is melted in a crucible, pulverized while hot, and put into a matras; highly dephlegmated alcohol is poured on, to three or four fingers depth; the matras is closed with another of a smaller size, luted together, and the whole is digested on a sand bath, till the spirit has acquired a reddish colour. A great or less quantity of alkali remains at the bottom of the vessel. This acid tincture of tartar affords, by distillation, alcohol of a sweet smell, scarcely altered; and a substance remains in the retort resembling a saponaceous extract, which, distilled with a naked fire, affords alcohol, ammoniac, and a light empyreumatic oil. In this operation, a small quantity of charcoal is formed, which is found to contain the potash. The experiment seems to show, that alcohol contains an oil which is seized by the fixed alkali, and forms a true soap kept in solution in the portion of alcohol which is not decomposed. The *lilium* of Paracelsus does not differ from the acid tincture of tartar, excepting that the fixed alkali employed in its preparation appears to be rendered caustic by the strong heat to which it was subjected. The martial, jovial, and cupreous reguli of antimony, each in the quantity

of four ounces, are fused together, then reduced into powder, and detonated with eighteen ounces of tartar, and as many of nitre; the whole being melted, pulverized, and put into a matrass, highly rectified alcohol is poured on, to the height of three or four inches above the mixture. By digestion on a sand bath, the spirit assumes a beautiful red colour, deeper than that of the preceding tincture, but presenting the same phenomena. The former tincture may be made entirely similar to the liliun of Paracelsus by digesting alcohol in the caustic fixed alkali, instead of using fixed salt of tartar, which is not deprived of its carbonic acid, unless it has been kept red hot a long time. Berthollet ascertained that these tinctures are merely solutions of caustic potash in alcohol, and that they afford an useful method of obtaining the alkali very pure, by evaporation of the spirit. Alcohol has the same action on pure soda. The acrid tinctures of tartar are excellent bracers, and powerful deobstruents. They are used in those cases where the natural forces of the patient are insufficient to favour the crisis, as in the malignant fever, the worst kind of small pox, &c.

The action of the caustic ammoniac on alcohol has not been examined.

All the acids present very important phenomena with alcohol. When concentrated sulphuric acid is poured on an equal quantity of rectified alcohol, a strong heat, with a remarkable hissing noise, is produced; the two substances become coloured, and emit a sweet smell, resembling that of lemons, or the apple called golden rennet. If the retort, in which this mixture is usually made, be placed on a sand-bath, with large receivers adapted, the first being plunged in a vessel of cold water, the products are, 1. An alcohol of a sweet smell; 2. A fluid called *ether*, of a very agreeable smell, extremely volatile, whose presence is ascertained by the ebullition of the liquor contained in the retort, and by the large striæ which run down the sides of the vessel. The receiver must now be kept cool by wet cloths. 3. After the ether, a sulphureous acid passes, whose white colour and smell indicate the proper time for changing the receiver, in order to have the ether separate. 4. At the same time a little yellowish oil is volatilized, which

is called *sweet oil of wine*. The fire must be greatly lowered after the ether is passed, because the matter contained in the retort is black, thick, and swells up considerably. 5. When the sweet oil is all distilled, sulphureous acid next comes over, which becomes thicker and thicker; and towards the end dirty and blackfulphuric acid. 6. The operation being continued by a gentle heat, the residue becomes perfectly dry, and has the form and consistence of a bitumen. By exposure to a strong heat, an acid liquor, and a dry and yellowish substance resembling sulphur, is obtained. Baumé, who has made a great number of experiments on sulphuric ether, has very carefully examined this residue, and found it to contain sulphat of iron, Prussian blue, a saline substance, and a peculiar earth, whose nature he has not ascertained. He even affirms, that the yellowish sublimate it affords is not sulphur, but that it remains white and pulverulent, without taking fire on the coals. To these details we shall add, that the residue of ether affords new ether, by the addition of one-third of alcohol dephlegmated by potash, and distilling the mixture, as Cadet has shown. These distillations may be repeated several times, and from a mixture of six pounds of sulphuric acid and alcohol, to which fifteen pounds of the latter fluid are successively added, more than ten pounds of good ether may be obtained.

The operation we have described, is one of the most singular in chemistry for the phenomena which it exhibits; and at the same time one of the most important, with respect to the explanation it affords concerning the composition of alcohol. There are two opinions respecting the formation of ether, which it is necessary to explain. Macquer, who, as we have observed, considers alcohol as a compound of water and phlogiston, thinks that the sulphuric acid takes the water from this substance, and causes it to approach gradually to the characters of oil. According to this opinion, therefore, alcohol first passes over scarcely altered; next a fluid, which occupies the middle space between alcohol and oil, which is ether; and lastly, a true oil, because the sulphuric acid acts so much the stronger on the principles of the alcohol, as the heat is more considerable. Bucquet made a strong objection to this theory; namely, that it is difficult to conceive how the sulphuric acid,

charged from the first with a certain quantity of water it had taken from the alcohol, could still, notwithstanding this dilution, react so strongly on a portion of the same spirit, as to put it into the oily state. He therefore proposed another opinion respecting the production of ether. He considered alcohol as a fluid composed of oil, acid, and water; and imagined, that when the sulphuric acid is mixed with the alcohol, a kind of bituminous fluid is produced, which affords by heat the same principles as all bitumens, namely, a light, odorous, very combustible oil, or a species of naphtha, which is the ether, and afterwards a less volatile and more coloured oil, which is the sweet oil of wine. We shall, in fact, perceive, by the properties of ether, which we are about to explain, that this fluid has all the characters of a highly attenuated oil, such as naphtha. This theory does not explain, with sufficient perspicuity, what happens during the preparation of ether. The oxygen appears to be taken from the sulphuric acid by the alcohol, and that part of the hydrogen, or principle of the spirit, forms water with this oxygen, while the alcohol, deprived of this portion of hydrogen, forms ether. But the whole which passes in this operation is not exactly known^b.

Ether, obtained by the process we have described, is not in a state of purity, but contains alcohol and sulphureous acid. It must be rectified by distillation in a retort, on a sand-bath, with the addition of fixed alkali. The salt combines with the sulphureous acid, and the ether passes over in a state of great purity by the gentlest heat. The first part of this product being received separate, is the purest and most highly rectified ether.

Ether is a fluid much lighter than alcohol, of a strong, sweet, and very expansible smell, and of a hot and penetrating taste. It is so volatile, that it is instantly dissipated by agitation, or pouring out. During its evaporation, it produces a degree of cold sufficient to freeze water, as Baumé has shown in his beautiful experiments. It takes the form of gas, which burns with great rapidity. Air, which holds ether in solution, may be passed through water without losing its smell and inflammability. Ether takes fire very readily when heated in the open air, or brought into contact with an inflamed sub-

stance. The electric spark likewise sets it on fire. Its flame is very luminous, and leaves a black coaly mark on substances exposed to it. Lavoisier has proved, that carbonic acid is formed during the combustion of this liquor; and Scheele found, that the residue of ether burned on a small quantity of water, contains sulphuric acid.

Ether dissolves in ten parts of water, according to the Count de Lauraguais. The phenomena produced by adding to ether all the saline substances, have not yet been examined; little more being known, than that the action of some acids, lime, and fixed alkalis, do not appear capable of changing it. Caustic ammoniac mixes with it in all proportions, and forms a fluid, whose odour may be very useful in spasmodic disorders. Sulphuric acid becomes much heated by mixture with ether, and converts a considerable part of it into sweet oil of wine by distillation. The fuming nitrous acid excites a considerable effervescence; the ether appearing to become more consistent, oily, and of a deeper colour in this experiment. Mixed with the muriatic solution of gold, it retains a part of that metal, and in this case appears to act like the volatile oils, which likewise retain a portion of the oxyd of gold. Like alcohol, it dissolves volatile oils and resins, and accordingly physicians often use ethereal tinctures.

Ether is considered as a powerful tonic, and antispasmodic remedy. It is used in hysterical disorders, and spasmodic cholics, and is of excellent service in cases where digestion is ill performed on account of weakness of the stomach. It must be administered, however, with prudence, because its excessive use is dangerous. It is likewise successfully applied externally in headaches, burns, &c. Hoffman, who made many experiments with the sulphuric acid, and alcohol, used a medicine composed of sweet oil of wine dissolved in alcohol, which he called his mineral anodyne liquor. The Faculty of Medicine at Paris have added ether to this liquor, and prescribe it to be prepared by mixing two ounces of the alcohol which passes in distillation before the ether, two ounces of ether, and twelve drops of sweet oil of wine. This medicine is employed for the same purposes as ether, but is far from having the same efficacy.

The nitric acid acts very strongly on alcohol. Navier is the first who described an easy and cheap method of preparing nitric ether. He directs twelve ounces of very pure and well rectified alcohol to be poured into a very strong glass bottle, and plunged in cold water, or which is still better, in pounded ice: to this is to be added, in several portions, the liquor being agitated each time, eight ounces of concentrated nitric acid; after which the bottle must be closed with a good cork, covered with leather, and well secured. This mixture is then to be left in a remote or private place, to prevent accidents that might arise from the bursting of the bottle, which sometimes happens. After some hours, bubbles arise from the bottom of the vessel, and are gradually collected at the top, forming a stratum of true ether. This disengagement continues from four to six days. As soon as the liquor appears to be at rest, the cork must be pierced with an instrument, that a certain quantity of gas may escape, which, without this precaution, would rush out on opening the bottle, and carry the ether with it. As soon as the gas is dissipated, the bottle is to be uncorked, and the fluid it contains poured into a funnel, whose lower aperture being stopped with the finger, the residue may be separated from the ether which floats above, and must be kept in a separate vessel.

Mr. Woulfe describes another process for preparing nitrous ether. It consists in using very large vessels, that the disengaged air may have a considerable space to expand itself in. A matrafs of white glass, containing eight or ten pints, and terminated by a neck of seven or eight feet long, is placed on a tripod sufficiently high to admit of a chafing-dish being put underneath. To the neck of this matrafs, a tubulated head is adjusted, with a tube of seven or eight feet long adapted to its beak. The lower extremity of the tube is received in a vessel with two necks, whose lower part is drawn out into a tube, which is inserted in a bottle. To the other neck of this receiver is adapted the apparatus of bottles, which we have frequently mentioned as the invention of Mr. Woulfe. These vessels being well luted together, one pound of rectified alcohol, with an equal quantity of fuming nitrous acid are poured into the matrafs, through the perforation in the head; this perforation

is then closed with a ground stopper wrapped round with a piece of leather. As soon as the mixture is made, it becomes strongly heated, vapours are disengaged, which pass rapidly along the neck of the matrafs, and by applying a sufficient degree of heat to make the mixture boil, nitric ether passes into the receiver. This process, though very ingenious, has its inconveniencies. The adjustment of the apparatus is difficult, and the vessels are very expensive; besides which, the method is dangerous; because, notwithstanding the space afforded to the vapours, they are disengaged with so much rapidity, that the vessels frequently fly in pieces.

Bogues, in the year 1773, published another process for making nitric ether. He directs one pound of alcohol to be mixed with one pound of nitric acid, weakened so as to exhibit only twenty-four degrees of Baumé's hydrometer, in a glass retort, containing eight pints; to this a receiver of twelve pints is to be adapted, the air is suffered to escape by adjusting the barrels of two quills at the juncture of the lute, and the distillation must be performed by a very gentle heat. By this means he obtained six ounces of nitric ether, of considerable purity. It appears, from the account of the Abbé Rozier, that Mitouard, as early as the year 1770, used a process nearly similar to that of Bogues. This chemist exposed four ounces of fuming spirit of nitre with twelve ounces of alcohol to distillation in a retort, which he placed lightly on the sand, and by this method, which appears the most simple of any, he obtained nitric ether similar to that of Navier. Lastly, De la Planche, apothecary at Paris, has invented two methods of preparing nitric ether very conveniently. The first consists in putting nitre into a tubulated stone-ware retort, to which a large receiver, with an adopter, is fitted; concentrated sulphuric acid is first poured to the nitre through the tube, and afterwards alcohol. The sulphuric acid disengages the spirit of nitre, which reacts on the alcohol, and forms nitric ether, almost immediately. As it might be suspected that the ether prepared in this way was partly sulphuric, he has substituted, instead of this method, another; which is very ingenious. An adopter, and a receiver, which communicates by a recurved tube, with an empty bottle, are affixed to a tubulated glass retort, containing six

pounds of very dry nitre. The last vessel, namely the bottle, communicates by means of a syphon, with another bottle, containing three pounds of the purest alcohol. The whole being well luted, and the retort placed on a bath of ashes, three pounds of concentrated sulphuric acid is poured on the nitre through the tube, which is immediately closed with a ground stopper. The mixture is then heated to ebullition, and kept in that state till no more vapours pass over. In this experiment, the sulphuric acid disengages the acid of the nitre, which passes partly into the receiver, and partly into the second bottle. When the operation is ended, the receiver contains fuming nitrous acid, the retort sulphat of potash, and the second bottle, an ethereal liquor. This last is distilled in a retort with a receiver, in the usual method, no more than two-thirds of the liquid being brought over. The product is again distilled with a fifth part of fuming nitrous acid, poured in by a little at a time, through a glass funnel with a long neck; two-thirds of this liquid being likewise distilled over. Lastly, The second product is rectified by distillation from potash; the first four ounces being kept apart, and three-fourths of the remainder suffered to come over. The four ounces are very pure nitric ether; the three-fourths of the remainder are a nitrous mineral anodyne liquor. The residues of the two rectifications are dulcified spirit of nitre^c.

Nitric ether, obtained by these processes, is a yellowish fluid, as volatile and evaporable as sulphuric ether, whose smell it resembles, though it is stronger, and not so agreeable; its taste likewise is hotter, and more pungent than that of sulphuric ether. It contains a small portion of superabundant acid. A large quantity of air is continually disengaged from it, which causes the stoppers of the bottles containing it to fly out frequently. Its flame is brighter, and the smoke it emits when burned, is denser than that of the sulphuric ether; it leaves a larger coaly residue; and lastly, like the sulphuric ether, it takes gold from its solutions, and suspends a certain quantity.

The residue of nitric ether is of a lemon yellow colour, its smell is acid and aromatic, and its taste is penetrating, and resembles that of distilled vinegar. It affords, by distillation,

according to Baumé, a clear liquor of a milder taste than that of nitric ether, being an agreeable acid, which reddens syrop of violets, unites with water in all proportions, and effervesces with carbonat of potash. The retort contains a yellow friable matter, of the appearance of amber, which attracts the humidity of the air, becomes of a pitchy consistence, and is soluble in water without rendering it mucilaginous. This, which Baumé calls a gummy saponaceous substance, if the distillation be continued, affords a few drops of a very clear acidulous fluid, of an oily consistence, and slightly empyreumatic smell. A spongy, brilliant, tasteless, very fixed coal remains. Bucquet affirms, that if the liquor which remains after the formation of nitric ether be evaporated, it assumes the consistence of a mucilage, and at the end of a certain time, affords saline crystals resembling hairy caterpillars, which have been called crystals of Hiærne, from the name of the chemist who first described them. It has since been discovered, that this residue is the oxalic acid, which proves that the combustible base of that acid is contained in alcohol.

The muriatic acid does not sensibly act on alcohol, this acid being only dulcified by a simple mixture with the spirit, as are likewise the two others when mixed with a large proportion of alcohol. Baumé, in his dissertation on Ether, asserts, that he obtained a small quantity of muriatic ether, by causing muriatic acid and alcohol to meet in the form of vapour. Ludolf and Pott used sublimated muriat of antimony with the same intention. Baron Born directs the solution of oxyd of zink in the muriatic acid, and distillation of this salt concentrated by evaporation in close vessels, with alcohol. This process affords muriatic ether, with considerable facility. But no one has pursued this inquiry with so much diligence and success as the Marquis de Courtanvaux. According to the process of this chemist, a pint of alcohol is to be mixed in a retort with two pounds and a half of the muriat of tin, or smoking liquor of Libavius; a strong heat is excited, and a white suffocating vapour arises, which disappears when the mixture is agitated; an agreeable smell is then perceived, and the mixture assumes a lemon colour. The retort is to be placed on a hot sand bath, two receivers being luted on, the outer of which is plunged in

cold water. A dephlegmated alcohol first passes over, and afterwards the ether rises, which may be perceived by its smell, and the striae it forms in the neck of the retort. As soon as the smell changes, and becomes strong and suffocating, the receiver must be changed; a clear acid liquor then comes over, on the top of which float a few drops of sweet oil. This is succeeded by a yellow butyraceous matter, or true muriat of tin; and lastly, a brown ponderous liquor, which emits abundance of white vapours. A grey pulverulent matter, or oxyd of tin, remains in the retort. The ethereal product being poured on potash in a retort, a strong effervescence takes place, and an abundant precipitate is thrown down, which is produced by the tin which the acid carries over with it in the distillation. A small quantity of water is then added, and a second distillation is performed by a gentle heat; the first half of the product being ethereal. All the fluids, which pass after the muriatic ether, are loaded with tin; they attract the humidity of the air, and unite with water, without affording any precipitate. It was formerly very difficult to determine the cause of the strong action of the muriatic acid contained in the fuming liquor on alcohol, since the pure acid does not at all act on that inflammable fluid. But, since the discovery of Scheele, it appears to be owing to the oxygenated state of the muriatic acid; and that its property of converting alcohol into ether must be attributed to the excess of the oxygen it contains. This theory was first explained by me in the year 1781, and is now confirmed by the experiments of Berthollet and Pelletier.

De la Planche, the apothecary, has proposed to make muriatic ether, by pouring sulphuric acid and alcohol on decrepitated muriat of soda, in a tubulated retort. The muriatic acid gas disengaged by the sulphuric acid, meets the vapour of alcohol in the receiver, and combines with it. An ethereal acid is produced, which may be purified by a second distillation from potash. In this process, the muriatic acid appears to take a portion of the oxygen from the sulphuric acid.

Muriatic ether is very transparent, and very volatile; its smell is nearly the same as that of sulphuric ether; it likewise burns in the same manner, and affords a similar smoke. But it differs in

two properties ; the one, that when burning it exhales an odour as penetrating as the fulphureous acid ; the other, that its taste is styptic like that of alum. These two phenomena show, that this ether is different, and perhaps less perfect than the two foregoing ; and there is no doubt but when its other properties shall be examined, other differences, equally remarkable, will be discovered.

After having thus treated of the action of three mineral acids on alcohol, we shall resume the history of this fluid. The action of other acids on alcohol has been little examined. It is only known, that it readily unites with the boracic acid, which communicates a green colour to its flame ; and that it absorbs more than its bulk of carbonic acid gas. As to the neutral salts, Macquer has determined, that sulphuric salts are not dissolved in this menstruum but with difficulty ; that the nitric and the muriatic salts unite with it much more readily ; and that in general it dissolves saline substances with more facility in proportion as their acid is less adherent. Alcohol boiled on the sulphats of potash and of soda, dissolved no part. The carbonats of potash and soda do not unite with it, but most ammoniacal salts do. Deliquescent earthy salts, such as the combinations of lime and magnesia, either with the nitric or muriatic acids, are perfectly dissolved. Some metallic salts are likewise very soluble, such as sulphat of iron in the state of mother water, nitrat of copper, the muriats of iron and of copper, the oxygenated muriat of mercury, or corrosive sublimate ; all the cupreous salts communicate a beautiful green colour to its flame. Morveau has, since the time of Macquer, given a very accurate table of the degrees of solubility of salts by alcohol. This table is inserted in the *Journal de Physique*.

Alcohol does not dissolve sulphur either when in mass or in powder ; but these two bodies unite when they meet in the vaporous form, as the Count de Lauragnais has discovered. His process consists in putting sulphur in powder into a glass cucurbit, upon which flowers he places a smaller vessel, filled with alcohol. A head and receiver being adapted, and the apparatus being heated by a sand-bath, both substances rising together, combine and form a fluid, which passes into the receiver rather in a turbid state, and emits a fetid smell. It contains

about one grain of sulphur in the drachm of alcohol. I have discovered that the same combination may be obtained by distilling sulphureous waters, such as those of Enghien, with alcohol.

Alcohol has no action either on metallic substances or their oxyds^d. It partly dissolves certain bitumens, such as amber. It does not act on those which are black and corry. It has been observed, that alcohol distilled from fixed alkali, acts more strongly on amber, and that a mixture of alkali with this bitumen renders it more soluble, doubtless, by converting them into a kind of soap.

There are few vegetable matters on which alcohol does not act more or less. Extracts lose their colouring part; and when they are of the resin-extractive or extracto-resinous kind, great part is dissolved. Saccharine and saponaceous juices also unite with this fluid. Margraaff, by means of alcohol, obtained a saccharine essential salt from beet root, skirwort, parsnips, &c. But the matters with which it combines the most readily are the volatile oils, aroma, camphor, balsams, and resins. The name of *spirituous distilled waters* is given to alcohol impregnated with the aroma of plants. These fluids are obtained by distillation from odoriferous plants with alcohol. The spirit seizes the principle of smell, and rises with it, carrying up at the same time a certain quantity of volatile oil, which causes it to become white by the addition of distilled water; but this principle may be separated by rectification on a water bath with a very gentle heat, care being taken to draw off no more than three-fourths of the alcohol, in order to be certain of having only the aroma. These spirituous distilled waters acquire a more agreeable smell by keeping; the odorous principle appearing to combine more intimately with the spirit.

The aroma has so strong an affinity with alcohol, that this fluid takes it from volatile oils and water. In fact, when alcohol is distilled from volatile oils, or from water charged with the smell of a plant, it takes the odorous principle, and leaves the oil or water without smell. It is observed, that alcohol dissolves the ponderous and thick volatile oils more perfectly than those which are fluid and light. Water separates this compound by precipitating the oil in the form of white opake

globules ; but the aroma remains united to the alcohol. Alcohol readily dissolves camphor in the cold, but it dissolves a larger quantity by the assistance of heat. This solution, when well saturated, as, for example, two drachms of camphor to one ounce of alcohol, being diluted with water, added drop by drop, affords a crystalline vegetation observed by Romieu. It consists of a perpendicular stem, into which fibres are inserted, forming an angle of 60 degrees with the perpendicular stem. This experiment seldom succeeds, and requires many trials to ascertain the quantity of water, the degree of cooling, &c.

The names of tinctures, elixirs, balsams, quintessences, &c. are given to compounds of oily or resinous juices in alcohol, which is sufficiently charged to have a high colour, and to afford an abundant precipitate by water. Like spirituous distilled waters, they are distinguished by the denomination of simple, when they contain but one substance in solution ; or compound, when they contain many. These medicines are, in general, prepared by exposing the dry vegetable itself, whose volatile oil or resin is required to be extracted, or the pulverized extract of the plant, to the action of alcohol, which is assisted either by agitation, or the heat of the sun, or a sand bath. When the resins of a number of plants or vegetable substances are required to be dissolved in the same spirit, care must be taken to digest that substance first which is the most difficultly acted on by the alcohol, and to add the other substances in the order of their solubility. When the menstruum has exhausted its action, and is saturated, it is to be strained off. A compound tincture is sometimes extemporaneously made, by mixing several simple tinctures. Thus the *elixir proprietatis* is made, by mixing the tinctures of myrrh, saffron, and aloes. Resins and balsams may be separated from alcohol by the affusion of water, or by distillation ; but in either case the alcohol retains the odorous principle. Water is not capable of decomposing tinctures formed with the extracto-resinous or resino-extractive substances, such as the tinctures of rhubarb, saffron, opium, gum ammoniac, &c. because these substances are equally soluble in these two fluids.

Alcohol and brandy have very extensive and manifold uses. The last of these liquors is used to revive the exhausted spirits ;

but in excess it is dangerous, for it dries up the fibres, and occasions tremors, palsies, obstructions, and dropsy. Alcohol, either alone or mixed with camphor, is applied externally to stop the progress of gangrene.

Distilled spirituous waters are administered in medicine as tonics, cordials, antispasmodics, stomachics, &c. They are given diluted with water, or sweetened with syrups.

With these, water, and sugar, certain drinks are prepared, which are known by the name of *ratafias* and *liquors*. These drinks, when properly prepared, and taken in small doses, may be useful; but in general there are few people with whom they agree, and to many they may be hurtful. An excess in liquors of this kind is extremely dangerous; for, instead of invigorating and of increasing the tone of the stomach, as is generally believed, they produce most frequently the opposite effect. Those which are drunk but seldom, and with moderation, are the least injurious; are prepared cold, with one part of alcohol distilled on the aromatic substance by which it is to be flavoured, two parts of water, and one part of the finest sugar.

Tinctures have nearly the same virtues with the distilled spirituous waters, but they act with more energy; they are therefore to be used in much smaller doses, and given in wine, in potions, and even in aqueous liquors. The precipitate which they form in the last of these is equally suspended in the mixture, and, besides, the odorous part remains dissolved in the alcohol.

Lastly, Alcohol united to copal resin, to oil of spic, or the greater lavender, or to oil of turpentine, forms varnishes, which are called *Drying*, because, when a layer of this compound is laid on any body to varnish it, the alcohol is soon volatilized, and leaves on the varnished body a transparent resinous plating. The volatile oils which are mixed with this composition prevent it from drying too hastily, and by communicating to it somewhat of an unctuous nature, render it less brittle than it would otherwise be.

NOTES ON CHAPTER XXIII.

^a It does not appear to be fully determined whether alcohol exists ready formed in wine and fermented liquors, or whether it be the product of heat in distillation. Gren, from being unable to reproduce wine, by adding alcohol to the parts from which it had been separated by distillation, inferred, that alcohol, as such, did not previously exist in the wine, but only its constituent parts, and that these parts were united, and the liquor produced by the heat necessary in distillation. This opinion has been more recently maintained by Fabroni, who alleges in proof of it an experiment which does not seem to admit of easy refutation. The experiment consists in adding alcohol to wine, mixing them well together, and afterwards separating the alcohol by means of potash. If the potash be added to wine in its natural state, no alcohol will be separated, a proof, as Fabroni conceives, that the alcohol does not exist already formed, but is indeed a true product of heat. *Ann. de Chem.* Tom. XXXI. p. 48.

^b The society of Dutch chemists obtained an elastic fluid possessing very singular properties from a mixture of 75 parts of concentrated sulphuric acid, with 25 parts of alcohol. This gas was obtained also, by passing the vapour of alcohol or of ether over filix or alumine in a glass tube, or by passing it simply through a tube of pipe-clay heated red hot. It was not formed in a glass tube containing lime or magnesia. This gas is not altered, by remaining in contact with water; with a little oxygenated muriatic acid it forms an ethereal oil. It is this last property which has induced the Dutch chemists to give to it the name of *olifant gas*. Mixed with an equal quantity of oxygenated muriatic acid gas, and inflamed, it deposits a great quantity of carbon. By burning 0,25, or 0,20, or 0,15 parts of oxygenated muriatic acid with 0,75, or 0,80, or 0,85 of olifant gas, the carbon appeared immediately under the form of a very fine black smoke. The quantity of carbon appearing during inflammation, was greater in proportion to the smallness of the quantity of oxygenated muriatic acid gas employed. Too great a quantity of this gas converted it into carbonic acid. From this experiment it appears, that hydrogen has a stronger attraction for oxygen than the carbon has. The olifant gas seems therefore to be a true carbonated hydrogen gas.

The gas obtained during the action of the sulphuric acid on alcohol burns with an oily flame. The extrication of this gas is promoted by heat, and the residue is sulphureous acid mixed with carbon. It may be purified from the sulphureous acid gas it contains, by washing it with water and ammoniac. Its weight is to that of air, as 0,995, 1,000. It has a fetid smell, and burns with a strong and compact flame similar to that of an oily or resinous body. Sulphuric, sulphureous, nitric, and muriatic acids, have no action on this gas. The same is true of nitrous gas and alkalis. Ammoniac increases its volume without producing any other apparent effect. Phosphorus melted in it by heat did not produce any change. Mixed in an equal portion with oxygenated muriatic acid, an absorption took place, and a thick oil was deposited of a pearl-grey colour that was heavier than water. This oil became yel-

low in the air, its odour was agreeable and penetrating, and its taste was mildish. It was soluble in water, and liquid potash took from it the smell of oxygenated muriatic acid. Neither sulphuric acid nor sulphur manifested themselves during its combustion. By passing it through heated sulphur, sulphurated hydrogen gas is formed, and the sulphur acquires a black colour.

Carbonic acid gas is formed by burning this gas with oxygen gas, by the passage of the electric spark, or by passing it through a red hot tube filled with oxyd of manganese, and by inflaming it with oxygenated muriatic acid gas. This gas the Dutch chemists term *oily carbonated hydrogen gas*.

Three fourths of the elastic fluid, disengaged from ether by sulphuric acid, is capable of being converted into oil by the oxygenated muriatic acid.

A gas, not olifiant, was obtained by passing alcohol or ether through a heated glass tube; but the olifiant gas was immediately formed, by introducing bits of pipe clay into the tube. A gas incapable of forming oil was produced by passing the vapour of alcohol or ether through glass tubes, containing lime, magnesia, potash, charcoal, and sulphat of potash. The earths became black in these experiments. With sulphur, sulphurated hydrogen gas was obtained.

The gas which had once passed through a glass tube did not become olifiant by repassing it over flint, alumine, &c.

This kind of carbonated hydrogen gas does not suffer any diminution in its volume by passing it through heated glass tubes, nor does it furnish oil with oxygenated muriatic acid gas; but the tube and receiver are blackened, and covered with drops of an empyreumatic oil.

The gas not olifiant, obtained by distilling ether or alcohol through reddened glass tubes, has a specific gravity to that of air, as 0.709:1000. It has a fetid smell, and burns with an oily and compact flame. Water neither dissolves nor alters it. Lime water is not affected by it, nor does it suffer any change from acids or alkalis. Oxygenated muriatic acid reduces it about one-seventh of its volume. It affords sulphurated hydrogen gas, by passing it through melted sulphur. It deposits carbon in burning it with oxygenated muriatic acid, and forms carbonic acid by combining it with oxygen gas. To distinguish it from the former, the Dutch chemists term it *carbonated hydrogen gas, obtained from ether*.

The specific gravity of the gas obtained from alcohol, passed through red hot glass tubes, is to that of common air as 0.456 to a 1,000. It burns with pale flame, less oily, and similar to that of alcohol. The Dutch chemists give it the name of *carbonated hydrogen gas, obtained from alcohol*.

These gases seem to differ from each other solely in the proportion of the principles which they contain. By burning them with oxygen, the oily carbonated hydrogen gas was found to contain the greatest quantity of carbon, and that from alcohol the least. The most remarkable difference between them consists in the formation of an oil, by the mixture of the oxygenated muriatic acid, with the oily carbonated hydrogen gas. The vapours of alcohol and ether passing through red hot glass tubes, afford gases which do not exhibit the least mark of an oil being formed by mixing them with oxygenated muriatic acid. Even the gas which has the property of forming oil, loses this property by passing it through a red hot glass tube. In its passage it deposits carbon. The electric spark always destroys this property, but without producing any deposition of carbon. The volume and elasticity of these gases are not diminished by passing them through water.

Hecht and Vauquelin, by passing the olifiant gas through a red hot porcelain tube, obtained hydrogen gas and carbonic acid gas. During this process, carbon was deposited in the glass tube which terminated the porcelain tube. Perhaps this

difference in effect was occasioned by their employing a higher degree of heat than the Dutch chemists. The olifiant gas deposited its carbon on the alumine, in the tubes through which it was passed. The vapour of ether (etherous gas) burns with oxygenated muriatic acid gas, and produces with it the same oil as the olifiant gas. These chemists seem inclined to believe, that ether and olifiant gas differ only in the unequal quantities of caloric with which they are combined.

The olifiant gas seems to be more dense, and to contain less caloric than the other species of carbonated hydrogen gas. It was capable of being converted into these, by subjecting it to a higher temperature, or by passing through it the electric spark. The carbon and hydrogen in the olifiant gas are in a more condensed state, and more disposed to form an oil by the addition of oxygen.

We have therefore a proof of the direct formation of oil, in the combination of oxygenated muriatic acid with the olifiant gas. From the nature of the constituent parts we know that the oil is formed by carbon, hydrogen, and a little oxygen. A gas similar to the olifiant is disengaged from every vegetable substance heated in a retort; and it would seem that a similar gas is disengaged from every vegetable matter that is slowly burned. This gas, by burning in the air, deposits the carbon, or soot, which blackens and shuts up the tubes through which it passes. If we heat briskly woods and mucilages in close vessels, they afford little oil, more charcoal and more carbonic acid; in the air there is more flame and less charcoal or soot deposited. It is probable that it is the olifiant gas which is disengaged in the latter case. These chemists suggest, that perhaps we shall be able to form oil artificially by combining the carbonated hydrogen, disengaged from highly carbonated mineral substances, by uniting it with oxygenated muriatic acid gas.

Berthollet, *Mem. de l'Acad.* 1785, has shown, that the hydrogen of alcohol and of ether form water with oxygenated muriatic acid.

Vauquelin, *Ann. de Chem.* T. XXIII. p. 203, has given a very ingenious explanation of the formation of sulphuric ether. It had usually been imagined that sulphuric acid was decomposed during this process, and that ether differed from alcohol only in containing a greater quantity of oxygen. His explanation is founded on the following experiments:

1. Equal parts of concentrated sulphuric acid, and rectified alcohol, when mixed together, give out a heat equal to 70 degrees of Reaumur. Bubbles of gas are disengaged, the liquor is disturbed, becomes of an opal colour, and assumes, at the end of some days, a deep red colour.

2. Two parts of sulphuric acid, and one of alcohol, raise the temperature of the mixture to 75°, become immediately of a deep red colour, pass to the black in a few days, and exhale an ethereal smell.

3. When equal parts of concentrated sulphuric acid and alcohol are exposed to heat in close vessels, we observe that the liquor begins to boil at 78°, and to give out ether. If the operation be skilfully conducted no permanently elastic gas is disengaged till about one half of the alcohol has passed over in the state of ether. This ether contains water, but no admixture of sulphureous or carbonic acid gases.

If the receiver be changed when the sulphureous acid gas begins to come over no more ether will be obtained, but *mild oil of wine*, water, and acetous acid, without a single bubble of carbonic acid gas. When the sulphuric acid forms about 4-5ths of the mass remaining in the retort, an inflammable gas is given out which has the smell of ether, and which burns with a white oily flame. This is the carbonated hydrogen, or olifiant gas of the Dutch chemists.

If the receiver be changed, when the mild oil of wine ceases to flow, sulphureous acid gas, water, and carbonic acid gas alone are observed to come over into the receiver, and a black mass remains in the retort, consisting chiefly of sulphuric acid and thickened carbon.

It appears from these experiments, 1st, That a small quantity of ether is formed spontaneously by the combination of two parts of concentrated sulphuric acid with one of alcohol.

2d, That the sulphuric acid undergoes no change during the formation of the ether, or of the water which is formed along with it.

And, 3d, That the formation of ether ceases as soon as the sulphureous acid gas begins to appear.

There are three periods in the formation of ether; the first is that in which ether and water are formed without the assistance of heat. In the second, the disengagement of the ether takes place without being accompanied by any sulphureous acid: and the third is that in which oil of wine, acetic acid, sulphureous acid, and carbonic acid gas, are disengaged. The formation of water takes place during these three stages from the beginning to the end of the process.

Ether, therefore, may be formed with the assistance of external heat, and the carbon separated from alcohol without the decomposition of sulphuric acid. This acid seems to act merely by changing the order of the affinities. In consequence of its strong attraction for water, it determines the hydrogen of the alcohol to unite with the oxygen; but this action is limited; for if the acid be in a small quantity, an equation of affinities is produced, the effect of which is to maintain the mixture in a state of rest. Any quantity of alcohol may be changed into ether, and into vegetable acid, by adding to it a sufficient quantity of sulphuric acid. The acid itself, during this process, will undergo no change except that of being diluted with a certain quantity of water. The sulphuric acid, in this instance, instead of favouring the decomposition of water, determines to its formation, so that the action of this acid on vegetable oxyds, is the reverse of that which it exercises on simple combustible bodies, such as sulphur and metals, the oxydation of which it effects by means of water.

Ether does not differ from alcohol merely in containing less oxygen and hydrogen; for a quantity of carbon is, during its formation, separated, proportionably greater than that of the hydrogen, so that ether may be considered as alcohol containing a larger proportion of hydrogen and oxygen.

When alcohol is made to pass through a porcelain tube, heated red hot, it is converted into water, carbonic acid, and carbon. In the formation of ether, the sulphuric acid serves merely to retain the alcohol; and the high temperature to which it is subjected effects its decomposition.

The nature of the products from the decomposition of ether will, therefore, necessarily differ according to the degree of temperature; and this explains why at a certain period mild oil of wine, and acetic acid, instead of ether, come to be formed; for the acid being now more dense, a greater heat is required to produce boiling. The ether retaining, at this temperature, a greater quantity of carbon, causes the mild oil of wine to be produced.

The same effects nearly were produced by using a fixed caustic alkali; a kind of ether was volatilized, a mild oil of wine formed, and carbon deposited. With this, as with the sulphuric acid, the alcohol is fixed and rendered capable of supporting the degree of heat necessary for its decomposition.

The sulphuric acid used for the preparation of ether will saturate as much pot-

ash at the period when the mild oil of wine begins to be formed as before its mixture with the alcohol.

That the formation of the oil of wine, is owing to the increase of temperature, is proved from this fact, that if we add alcohol to the retort, in proportion as the ether is volatilized, no oil will be produced, but the alcohol will be wholly changed into ether.

It is to a higher degree of the same cause, that we attribute the formation of the carbonated hydrogen, or olifiant gas, which appears to be oil of wine deprived of a portion of its oxygen, and containing more caloric.

It appears then, that the formation of ether depends on the reaction of the elements of alcohol on each other, particularly of the oxygen and hydrogen; and that the operation is divided into two periods, one in which ether and water are formed, and another in which mild oil of wine, water and acetous acid, are produced; and that if we wish to avoid the formation of oil of wine, we must keep the mixture in a temperature of between 75 and 78 degrees.

The nature of the gas disengaged, during the distillation of a mixture of alcohol and nitric acid, has been also investigated by the Dutch chemists. The production of this gas, is more or less rapid according to the strength of the acid, and of the alcohol. After this gas ceased to be produced, nitrous gas was given out, and the liquor at last was found to consist chiefly of acetic acid. Little or no ether is formed during this process.

The gas has a disagreeable and ethereal smell, which it did not lose by standing; it burned slowly and with a yellowish flame, by bringing it into contact with the flame of a candle. It is wholly absorbed by water, which acquires the smell of the gas. Alcohol appears to absorb it in a shorter time, and in a greater quantity than water. It is absorbed, though slowly, by a solution of potash. The sulphuric and muriatic acids disengage it from this combination, with its properties unchanged; ammoniac has no action on this gas. Oxygen does not alter it, but if a mixture of these fluids be fired, a very violent explosion takes place. Sulphuric, nitric, and muriatic acids, change this gas into nitrous gas. By passing it through glass tubes red hot, a thick vapour came out of the tubes, which precipitated lime water, and was inflammable. The inside of the tubes was covered with an empyreumatic oil. The gas was now no longer absorbable by water, and it had the smell of nitrous gas. Oxygen, and the oxygenated muriatic acid, produced in it the red vapours, which are sure marks of the formation of the nitric acid; the residue was carbonated hydrogen gas. These experiments seem sufficient to show, that this substance was a compound of nitrous gas, and of a substance consisting of hydrogen and carbon.

By mixing this inflammable gas, with oxygenated muriatic acid gas, a very considerable diminution of volume took place. In this experiment, the oxygenated muriatic acid converted the nitrous gas into nitric acid, and was itself reduced to the state of ordinary muriatic acid; for the liquor which is formed, and which trickles down the sides of the vessels in which the gases are mixed, affords crystals of the nitrate and muriate of potash, when that alkali is added.

The Dutch chemists are of opinion, that, besides the nitrous gas, the other constituent part of this inflammable gas is ether, though in a state somewhat different from the ordinary state of that substance. They call this gas, therefore, *etherized*, or *etherated nitrous gas*.

If one part of nitric acid be mixed with six of alcohol, and digested on zink,

the gaseous oxyd of azot is first disengaged, and afterwards this peculiar kind of inflammable gas.

When this gas was exposed to the reagents which take oxygen from nitrous gas, such as a solution of copper in ammoniac, of muriat of tin, or an alkaline sulphure, it was converted into the gaseous oxyd of azot, which having no tendency to combine with the ether, quitted it, and, of course, restored to it its primitive inflammability.

d Van Marum, by distilling alcohol over copper wire contained in long porcelain tubes, heated red hot, found that the alcohol was decomposed, and hydrogen gas disengaged: The wire was incrustated with a black substance, and had become so brittle, that it fell into powder merely by touching it. Dr Priestley, who first observed these phenomena, appears to have used a greater degree of heat in his experiments, so that the quantity of black substance was much greater in proportion to the copper. Van Marum found that iron decomposed alcohol, but in an inferior degree. He could not effect the production of the black substance, by silver, lead, or tin. The same is true of zink, bismuth, antimony, cobalt, and manganese; yet in all these experiments very nearly the same quantity of hydrogen gas was evolved.

This black substance afforded carbonic acid gas by burning it with oxygen gas; and what remained of the carbon, in combination with the copper, after combustion, could be separated by nitric acid. We have, therefore, in this case, a *carbure of copper* similar to the *carbure of iron*.

The gas evolved during this decomposition was carbonated hydrogen gas, equal in weight to one half its volume of atmospherical air. *Ann. de Chem. T. XXX.*

CHAPTER XXIV.

OF THE ACETOUS FERMENTATION, AND OF THE ACETOUS AND ACETIC ACIDS.

MANY vegetable substances, such as gums and amylaceous fecula, dissolved in boiling water, are capable of undergoing the acid fermentation; but this property is more especially remarkable in fermented and spirituous liquors. All these fluids, when exposed to heat in contact with air, undergo the acid fermentation, and afford the liquor called Vinegar. The wine of grapes is more especially used in preparing this liquor, though it is possible to make very good vinegar with cyder, perry, &c.*

There are three conditions necessary to the acetous fermentation: 1. A degree of heat from 75° to 90° of Fahrenheit. 2. A substance at the same time viscous and acid, such as mucilage and tartar. 3. The contact of air. The change which wine undergoes when it is converted into vinegar must be attributed to an intestine motion, excited in the fluids by a certain quantity of mucilage, which is not changed, and is capable of passing through a new fermentation. The presence of an acid substance, such as tartar, is necessary to determine the acid fermentation. Lastly, The contact of air is indisputably necessary, and it appears that a certain portion is absorbed during this fermentation, as the Abbé Rozier has proved. It is probable that this is oxygen gas.

All wines are capable of forming vinegar. The bad wines are employed in preference, for the sake of cheapness; but the experiments of Beccher and Cartheuser prove, that generous wines, abounding with alcohol, afford in general the best vinegar.

Boerhaave, in his Elements of Chemistry, has described a very good process for making vinegar. Two large casks are provided, and a false bottom of wicker is fixed, at some di-

* Vinegar is made in Britain from wort, which is the infusion of malt, made in the same way as in the process of brewing.

stance from the bottom, within each, on which vine branches and grape stalks are spread : wine is then poured in ; so that one of the vessels is filled, and the other only half full. The fermentation commences in the latter : when it is well established, it is filled up with wine added from the other tun. By this means, the fermentation is retarded in the full vessel, and accelerated in the other. When it has arrived at a considerable degree in this last, it is again filled up, by transferring part of the fluid from the other ; the fermentation consequently recommences in the first vessel from which the liquor was last taken, and becomes slower in that which is filled up. The alternate filling and emptying of the vessels is continued till the vinegar is perfectly formed, which usually happens in twelve or fifteen days.

When the effects of this fermentation are attended to, much ebullition and hissing is perceived ; the liquor becomes hot and turbid, exhibits a great quantity of filaments and bubbles, agitated in every direction ; a strong acid smell, not at all dangerous, is emitted, and a large quantity of air is absorbed. It is necessary to impede the fermentation every twelve hours. These phenomena gradually become less, the heat decreases, the motion decays, and the fluid recovers its transparency : a sediment is deposited, in reddish flocks, which adhere to the sides of the vessels. Numerous experiments have shown, that the smaller the quantity of wine, and the more perfect the access of air, so much the more readily does it pass to the state of vinegar. The vinegar must be carefully drawn off, in order to separate it from its lees, which, without this precaution, would quickly cause it to undergo the putrid fermentation. Vinegar does not deposit tartar by standing, like wine ; this salt is dissolved, and combined with the alcohol and water during the fermentation. It is even probable, that the presence of this salt influences the developement of the properties of vinegar. This fluid has more or less colour, according to that of the wine used in its preparation ; but in general, vinegars, which have the least colour, are far from being of as light a colour as the white wines, because they hold in solution the colouring matter of the tartar, which has likewise been developed by the production of the acid.

Vinegar, prepared in the method here described, is very fluid; of an acid and spirituous smell, and of a sour taste, of different degrees of strength: it reddens blue vegetable colours. When exposed to a warm temperature, in imperfectly closed vessels, it becomes changed, losing its spirituous part, and depositing a great quantity of mucilaginous flocks and filaments, at the same time that it assumes a putrid smell and taste. In order to preserve it, it is necessary to boil it for a short time, as Scheele has observed*.

When vinegar is distilled by a naked fire, in an earthen alembic, or in a glass retort, on a sand-bath, a phlegm of a lively and agreeable smell, but scarcely acid, first passes over; this is succeeded by a very white acid liquor, called distilled vinegar. The following products have less smell, and more acidity, as the distillation advances. If these products be taken separately, distilled vinegars, differing from each other in acidity and smell, may be obtained; but it is usual, in this process, to draw off about two thirds of the liquor, which constitutes the purest vinegar. The portion which comes over afterwards is more acid, but it has an empyreumatic smell, which may be dissipated by exposure to air; it is likewise slightly coloured. This operation shows, that the acetous acid is less volatile than water. The remaining vinegar is thick, of a deep and dirty colour, deposits a certain quantity of tartar, and is considerably acid. If it be evaporated in open vessels, it takes the form of an extract; and if, when dried, it be distilled in a retort, it affords a reddish acid phlegm, an oil at first light coloured and afterwards heavy, with a small quantity of ammoniac. The remaining coal contains much fixed alkali.

Vinegar may be concentrated by exposing it to frost. The frozen part consists almost entirely of water; the part which remains fluid, being decanted off, is found to be much more acid: the quantity of vinegar thus obtained is small.

The acid of vinegar, separated from tartar and the colour-

*. This discovery, announced in Scheele's Essays, p. 315. English translation, did not succeed with me upon the trial. T.

ng matter, by distillation, is capable of uniting with a great number of bodies.

It does not readily combine with alumine, with which it forms crystals, in small needles, whose properties are little known. It is the acetit of alumine.

This acid unites readily with magnesia, and affords a salt, which is very soluble in water, and does not afford crystals but is converted into a viscous deliquescent mass, by evaporation. The acetit of magnesia is decomposed by fire, by the mineral acids, by barytes, by lime, and by the alkalis. It is very soluble in alcohol.

The acetous acid combines with lime, and decomposes chalk whose acid it disengages, in the form of an elastic fluid. The salt it forms with lime, crystallizes in very small needle shaped prisms, of a fat appearance. The calcareous acetit is bitter, and sour, and effloresces in the air. Fire decomposes it; its earth is separated by fixed alkalis; and the mineral acids disengage its acid^a.

The combination of the acetous acid with potash, is called *terra foliata tartari*, and ought to be called the acetit of potash. This salt is prepared, by pouring very pure distilled vinegar on carbonat of potash, prepared by incineration of tartar; the mixture is agitated, and the vinegar added, till the saturation is perfect, and the salt well dissolved. It is proper to add an excess of acid. The liquor, being first filtered, is evaporated, by a gentle heat, in a vessel of porcelain, or pure silver; and when it becomes thick, the evaporation is continued to dryness, on a water bath. By this means, a very white salt is obtained. If too strong a degree of heat be used, it becomes grey, or brown, by the burning of a portion of the vinegar. Some chemists affirm, that this salt may be obtained in a regular form, by cooling the solution previously evaporated to a thick pellicle. The acetit of potash has a penetrating, acid, and urinous taste. It is decomposed by the action of fire; and affords, by distillation in a retort, an acid phlegm, empyreumatic oil, ammoniac, and a large quantity of a strong-smelling gas, consisting of a mixture of carbonic acid, and of hydrogen gas. The residual charcoal contains much disengaged potash. This salt strongly attracts the humidity of the air, and is very soluble in water.

The sulphuric acid decomposes it. For this purpose, one part of concentrated acid is poured on two parts of the acetit of potash, introduced into a tubulated glass retort, to which a receiver is adapted: a vaporous fluid, of a penetrating smell, is immediately disengaged, with a strong effervescence, which condenses in the receiver, into acetic acid, or *radical vinegar*. This vinegar is very concentrated, and strongly acid; but it is not pure, as it always contains a certain quantity of sulphureous acid, distinguishable by its smell. Tartareous acidule likewise decomposes the acetit of potash, because it has a stronger affinity than the acetous acid with the alkaline base of this salt.

Vinegar unites perfectly with soda, and forms a salt, improperly called *crystallizable terra foliata*. It is now called acetit of soda. This does not differ from the acetit of potash, but in its crystallizing in striated prisms, resembling those of the sulphat of soda, and in its not attracting the humidity of the air. To obtain perfect crystals, the solution must be evaporated to a pellicle, and set in a cool place. The acetit of soda is decomposed by fire, and the mineral acids; and we may observe, that if alkaline acetous salts be distilled by a strong heat, the residues are pyrophori, which take fire when exposed to the air. Proust, the discoverer of these facts, is of opinion, that a pyrophorus is produced in all cases, where a carbonaceous residue is divided by an earth or a metallic oxyd.

The acid of vinegar, with the ammoniac, forms a liquor, known by the name of *spirit of Mindererus*. It is the acetit of ammoniac. This salt is so volatile, that it cannot be evaporated without losing the greatest part of it. Nevertheless, crystals, in the form of needles, attracting strongly humidity from the atmosphere, and of a hot and penetrating taste, may be obtained by slow evaporation. The ammoniacal acetit, is decomposed by the action of fire, by lime and fixed alkalis, which disengage the ammoniac, and by the mineral acids, which separate the acetous acid.

Vinegar acts on almost all metallic substances, and its combinations are attended with a variety of important phenomena.

It does not appear to dissolve the oxyd of arsenic; but this last substance distilled with an equal part of the acetit of potash, afforded Cadet, and the chemists of the Academy of

Dijon, a red fuming liquor of a nauseous smell, very tenacious, and of a singular nature. Cadet had before observed, that this liquor inflames fat lute. The academicians of Dijon being desirous of examining a yellowish matter of an oily consistence, collected at the bottom of the vessel, which contained the arsenico-acetous fuming liquor, decanted a portion of this superfluent liquor, and poured the rest on a filter of paper. A few drops had scarcely passed, when immediately an offensive and very thick fume arose, which formed a column from the vessel to the ceiling; a kind of ebullition was excited on the borders of the matter, and a beautiful rose-coloured flame issued forth; all which lasted a few seconds. A full account of the experiments of these learned academicians, may be seen in the third volume of the Elements of Chemistry of Dijon. They compared the liquor we have spoken of to a liquid phosphorus; we think it is a pyrophorus of the same kind as those we shall presently mention. The residue of the distillation of the acetit of potash with oxyd of arsenic, consists for the most part of potash.

Vinegar dissolves the oxyd of cobalt, and forms a solution of a pale rose colour.

It has no action on bismuth, or its oxyd, but it dissolves that of manganese.

It dissolves nickel directly, according to Mr. Arvidson; this solution affords green crystals, of the form of a spatula.

The acetous acid does not appear to act on antimony, but it appears to dissolve the vitreous oxyd of this metal: since Angelus Sala made an emetic preparation with these two substances.

Zink, and also its oxyd, are readily dissolved by distilled vinegar. Monnet obtained crystals from this solution in the form of flat plates. The acetit of zink fulminates on hot coals with a blueish flame. By distillation it affords an inflammable liquor, a yellowish oily fluid, which soon becomes of a deep green; and a white sublimate, which when set on fire by a candle, burns with a beautiful blue flame; the residue is in the state of a pyrophorus, not very combustible.

The acid of vinegar does not dissolve mercury in its metallic state; but this combination may be made by dividing

the mercury into very small particles, as was done by Keyser Mercury, in the state of oxyd, readily unites with vinegar. The acid may be boiled either on the red oxyd of mercury, named *precipitate per se*, on *turbith mineral*, or mercury precipitated from its nitric solution by potash. The fluid becomes white, but recovers its transparency when boiling hot; it is then to be filtered, and silver-coloured crystals fall down, in scales resembling boracic acid. This acetit of mercury has been called *mercurial foliated earth*. It may be immediately prepared by pouring a nitric solution of mercury into a solution of acetit of potash; the nitric acid unites with the fixed alkali of this last salt, and forms nitre, which remains dissolved; while the oxyd of mercury, combining with the acid of the vinegar, is precipitated in the form of brilliant scales. The mixture being then filtered, the mercurial acetit will remain on the filter. This salt is decomposed by the action of fire, and its residue affords a kind of pyrophorus. It is quickly altered by combustible vapours.

Tin is not much altered by vinegar. This acid dissolves only a small quantity of that metal, which solution, by evaporation, afforded Monnet a yellowish substance resembling gum, and of a fetid smell.

The acid of vinegar acts more strongly on lead than on most other metals, and dissolves it with the utmost facility. When thin plates of this metal are exposed to the vapour of heated vinegar, they become covered with a white powder called *ceruse*, which is an oxyd of lead, containing a little vinegar. Ceruse ground with one third part of chalk, forms the white lead used as a paint. In order to saturate vinegar with lead, the acid is poured on ceruse in a matrafs; the mixture is set to digest on a sand bath, and after several hours is evaporated to a pellicle; by cooling it affords white crystals, forming either irregular needles, if the fluid has been too much concentrated; or flat parallelipedons, terminated by two slant sections, when the evaporation has been well made. This acetit of lead is called *salt or sugar of Saturn*, on account of its sweet taste, which is at the same time very styptic. A salt of the same nature is made, by boiling equal parts of litharge and of vinegar, and evaporating it to the consistence of syrup. This

is the *extract of Saturn* of Goulard, which long before his time was known by the name of vinegar of *Saturn*. Acetite of lead is decomposed by heat; it affords an acid, ruddy, and very fetid liquor, different from radical vinegar or pure acetic acid, of which we shall presently treat. The residue is a very good pyrophorus. This salt is decomposed by distilled water, by lime, by alkalis, and by the mineral acids. The *extract of Saturn*, diluted with water, and mixed with a small quantity of brandy, forms the *vegeto-mineral water*.

Vinegar quickly dissolves iron; the effervescence which takes place in this solution arises from the disengagement of hydrogen gas afforded by the water, which seems to be decomposed. The liquor has a red or brown colour; and by evaporation affords only a gelatinous magma, together with some long brown crystals. The acetite of iron has a styptic and sweetish taste; is decomposed by fire, which drives off its acid; attracts the moisture of the air, and is decomposed in distilled water. When heated till it no longer emits a smell of vinegar, it leaves a yellowish oxyd attracted by the load-stone. The acetous solution of iron affords a very black ink with nut-galls, and may be successfully used in dying. The alkaline prussiate precipitates a very bright Prussian blue. The black, yellow, and brown oxyds of iron, the native carbonat of iron, or the *sparry iron ore*, afford solutions with vinegar of a very fine red colour.

Acetous acid dissolves copper with very great facility, and by the assistance of heat it gradually assumes a green colour. But this acid acts more readily on this metal when already oxydized by vinegar, and converted into the substance called verdigris. Verdigris is prepared in the neighbourhood of Montpellier, by plates of copper in earthen vessels, covered in layers with the husks of grapes, which have been previously sprinkled and fermented with weak vinegar. The surface of these plates soon become covered with a green rust, which is increased by piling them together, and sprinkling them with weak vinegar. The copper is then scraped, and the verdigris is packed in sacks of leather for sale. Montet, apothecary at Montpellier, has very well described this process, in two *Memoirs* printed among those of the Academy of Sciences, for

the years 1750 and 1753. Verdigris readily dissolves in vinegar, and the solution, which is of a beautiful green colour, affords by evaporation and cooling, green crystals, in truncated quadrangular, pyramids, called *verdet* or *crystals of Venus*. The crystals prepared for commerce, which are called *distilled verdet*, because distilled vinegar is used in preparing them, have the figure of a pyramid; its crystals assume this form, because they are deposited on a stick cleft into four branches, which are kept asunder by a piece of cork^b.

The *verdet* or acetit of copper has a strong taste, and is a violent poison. It is decomposed by the action of fire, effloresces in the air, and becomes covered with a powder, whose green colour is much paler than that of the salt itself. It is completely dissolved in water without decomposition. Lime water and alkalis precipitate the oxyd of copper.

When this salt is pulverized and distilled in an earthen or glass retort, a fluid is obtained at first pale and scarcely acid; but affords afterwards one so strong, as to resemble the concentrated mineral acids. The receiver must be changed during the operation, in order that the phlegm and the acid may be had separate; the latter is called *radical vinegar*, or *vinegar of Venus*. It has a green colour, arising from a certain quantity of the oxyd of copper which comes over. When the distillation ceases, and the bottom of the retort is red hot, the residue is a brown copper coloured powder, which often communicates a metallic tinge to the sides of the vessel. This residue is strongly pyrophoric, as the Duc D'Ayen and Proust have observed. *Radical vinegar* is rectified by distillation with a gentle heat; it is then perfectly colourless, provided the heat has not been urged too strongly, so as to dry the remaining oxyd of copper. The reduction of the copper reserved in this experiment explains the nature of *radical vinegar*. This acid appears to have the same relation to common vinegar, as the oxygenated muriatic acid has to the pure muriatic acid, or rather that which the sulphuric has to the sulphureous, or the nitric to the nitrous. In this operation the acetous acid unites with the oxygen of the oxyd of copper, which at the same time resumes the metallic state. The very different effects produced by radical vinegar, compared with those of the com-

mon acetous acid, appear therefore to arise from its excess of the oxygen. According to the principles of the nomenclature we have adopted, this salt is termed *acetic acid*.

Acetic acid, or radical vinegar, thus rectified, has so strong and penetrating a smell, that it is impossible to support it for any length of time; its causticity is such, that it corrodes and burns the skin, and it is extremely volatile and inflammable. When heated with contact of air, the rapidity with which it burns is the greater the more highly it is rectified. This experiment has induced chemists to believe that vinegar is an acid combined with an alcohol; it may, perhaps, be considered as a kind of natural ether. This notion is rendered probable by the penetrating and agreeable smell emitted by the first portions of this acid in distillation. Acetic acid evaporates entirely when exposed to the air; it unites to water with much heat; with earths, alkalis, and metals, it forms different salts from those of the acetous acid; they are called acetats of potash, soda, mercury, zinc, &c. Laffone has shown, that the ammoniacal salt formed by radical vinegar, or the acetic acid, is very different from that formed by the common acetous acid, and called Spirit of Mindererus. Although we do not possess a sufficient knowledge of the properties of all the acetats, yet their form, taste, solubility, &c. sufficiently show that they really differ from the acetits. The Marquis de Courtanvaux has shown, that it is only the last portion of the acetic acid obtained by distillation from crystals of verdigris which is inflammable; and that it likewise has the property of being congealed by cold. This last portion, when rectified, crystallized in the receiver in large plates and needles, and did not become fluid at a less heat than about 62 degrees of Fahrenheit. In this property likewise it resembles the oxygenated muriatic acid.

Acetic acid decomposes alcohol, and forms ether with the same facility as the mineral acids, as the Count de Lauraguais has discovered. For this purpose, acetic acid is poured on an equal quantity of alcohol in a retort. A considerable degree of heat is excited. The retort is then placed in a sand bath, with two receivers fitted on, the outer being plunged in cold water or pounded ice. The mixture being quickly brought to ebul-

lition, a dephlegmated alcohol passes first, afterwards the ether, and lastly, an acid, which is stronger as the distillation advances: a brown mass, considerably resembling a resin, remains in the retort. Care must be taken to change the receiver as soon as the ethereal smell becomes sharp and penetrating, that the acid may be collected apart from the ether. The acetic ether must be rectified by a gentle heat with potash. A large proportion is lost in this operation. The formation of this ether is owing to the excess of the oxygen in radical vinegar. Scheele affirms, that he did not succeed in preparing acetic ether by adding radical vinegar to alcohol, and that he did not obtain it, but by the addition of a mineral acid. Mr. Perner had before made the same remark concerning the difficulty of obtaining acetic ether by the process of de Lauraguais. However, many French chemists have executed that process; and I can myself affirm, that I have repeated it with success.

De la Planche, the apothecary, prepares acetic ether, by pouring concentrated sulphuric acid and alcohol on acetit of lead, introduced into a retort. The theory and practice of this operation are absolutely the same as those of the nitric and muriatic ethers prepared by a like process.

The acetic ether has an agreeable smell like other ethers, but it always partakes of the smell of vinegar, though it is not acid. It is very volatile and inflammable, burns with a bright flame, and leaves a coaly mark after its combustion.

Many researches still remain to be made by chemists respecting the nature of acetic acid. What we have said concerning its properties will serve to show, 1. That it differs remarkably from acetous acid, or common vinegar. 2. That this difference depends on the greater quantity of oxygen contained in the acetic than the acetous acid, which excess it had taken from the oxyd of copper^c. Let us now resume the examination of the other properties of common vinegar.

The acetous acid, assisted by heat, dissolves the precipitate of gold made from oxygenated muriatic acid by adding a fixed alkali. This acetous solution of gold precipitated by ammoniac affords *fulminating gold*, as Bergman has shown. Vinegar does not act on platina or silver while they are in the metallic state, but it dissolves their oxyds.

Vinegar combines with many of the immediate principles of vegetables. It dissolves extracts, mucilages, and essential salts; unites with the aroma, and is considered as the proper solvent of gum resins. It has even, after a certain length of time in the way of distillation, a considerable action on fat oils, which it converts into a saponaceous state. But the combination of vinegar with vegetable substances has been by no means accurately examined.

This acid is used to extract some of the vegetable principles, more especially that of smell; and vinegars of different nature, either simple or compound, are prepared for medical use. The vinegars of squills, colchicum, &c. afford an example of the first; the theriacal vinegar, and the vinegar of the four thieves, are of the second kind. These medicines are prepared by maceration and digestion continued for several days. As the acid is volatile, it is distilled from aromatic plants, whose odorant principle it takes up; the distilled vinegar of lavender used as a perfume is of this kind; these liquors are in general less agreeable than spirituous distilled waters.

Vinegar is much used, as to season food. It is likewise of excellent use in medicine, as a refreshing and antiseptic fluid. A syrup is made with sugar, which is given with great success in burning or putrid fevers, &c. This acid, externally applied, is astringent and bracing. All its combinations are likewise applied to medical uses.

The acetit of potash and of soda, which are known by the names of *terra foliata tartari*, and *mineral acetous salt*, are powerful deobstruent and aperient remedies; they are administered in the dose of from half a drachm to a drachm.

The spirit of Mindererus, or solution of ammoniacal acetit, taken in the dose of a few drops in a proper liquid, is aperient, diuretic, cordial, antiseptic, &c. It often succeeds in the leucophlegmatia, or swelling of the external parts of the body.

The acetit of mercury, or *mercurial terra foliata*, is an excellent anti-venereal; it is the principal ingredient in Keyser's pills.

The extract of Saturn, vinegar of Saturn, and the *vegeto-mineral water*, are applied externally as desiccatives. These medicines, being strongly repellent, ought to be administered with great

caution, especially when applied to parts which are ulcerated or without skin. Boerhaave mentions several young women attacked with consumptions, in consequence of the external use of preparations of lead.

Ceruse enters into the composition of drying unguents and plasters, and verdigris is a component part of several collyria and unguents.

Acetic acid, or *radical vinegar*, is used as a very powerful stimulant to be respired by such as fall into fainting fits. For the convenient use of this remedy, a certain quantity is poured on sulphat of potash grossly powdered, which is kept in a well closed bottle; this medicine is universally known by the name of *salt of vinegar*.

Acetic ether has not yet been applied to any use; neither is it known whether it has any peculiar virtues, differing from those of other ethers.

NOTES ON CHAPTER XXIV.

ACETIT OF ZIRCON.

^a Acetous acid dissolves zircon in a divided and humid state. This combination, which is very soluble in water, does not appear to be capable of crystallization. This salt undergoes less change from the heat, than nitrat of zircon, probably, because it adheres less strongly to the water of solution, and because it is dried at a lower temperature.

Like the other salts of this class, it possesses a very strong astringent taste. It is soluble in alcohol, but does not deliquesce in the air.

^b Considerable alterations and improvements in the process for making *verdigris* have been introduced since the time of Monnet. These are fully and most accurately detailed in a memoir by Chaptal, in the *Ann. de Chem.* Tom. XXV. p. 305.

Acetous acid acts upon copper only in the state of an oxyd. Chaptal found that this acid, when saturated with oxygenated muriatic acid gas, produced a partial solution of copper; but the white micaceous product formed did not resemble acetat of copper. The acetous acid, which has been repeatedly distilled over the oxyd of manganese, dissolves copper but very feebly, and in small quantity.

^c Adet, *Ann. de Chem.* Tom. XXVII. p. 299. has lately endeavoured to prove, by a variety of experiments, 1. That there is no acetous acid properly so called. 2. That the acid of vinegar exists always in the highest degree of oxygenation, of which it is capable; consequently that it is always in the state of acetic acid; and, 3. That the

only difference which exists between the acetic, and that which has been called the acetous acids, arises from the smaller quantity of water which the acetic acid contains.

The accuracy of these results has been combated, and apparently with much success, by Chaptal. This chemist allows that Adet has shown that the quantity of oxygen contained in the acetous and acetic acids is nearly the same, and that the greater part of the salts formed separately by these two acids are of the same nature; but in admitting these facts, he is far from thinking that the two acids differ only in the quantity of water which they respectively contain.

In order to bring Adet's hypotheses to the test of experiment, Chaptal reduced the acetic acid to the same degree of specific gravity with the acetous acid, by adding to it a quantity of distilled water. The smell and taste of the two acids were still very different; and the action of the acetic acid on metallic oxyds was more speedy and more energetic than that of the acetous. Acetic acid, for instance, dissolved the oxyd of copper, precipitated from the sulphat by potash, and formed with it beautiful crystals on cooling. The acetous acid, with the same oxyd, acquired merely a blueish green colour, and a green and saline crust was precipitated on the side of the vessel containing the liquor. Eleven parts of acetic acid require for saturation 6.98 of pure potash, while the same quantity of acetous acid require only 5.73.

When sulphuric acid was added to equal parts of acetic and acetous acids, of the same degree of concentration, a very considerable degree of heat was produced. The mixture with the acetic acid appeared at first of a pale yellow colour, while in the acetous no change was produced. The mixture with the acetous acid boiled sooner than the other, and after the evaporation of about one third, it assumed the tinge of very deep coloured wine. The mixture with the acetic acid was much paler. During distillation much sulphureous acid was disengaged, and at the end of the operation the residues had lost their colour, and consisted merely of concentrated sulphuric acid. The acetous acid appeared to Chaptal to be brought to the state of acetic, by its decarbonization in the retort.

100 parts of potash were saturated with each of the two acids, and the salts which they formed subjected to distillation in a retort. By this process, residues of a black colour were obtained. The acetat afforded 17 parts of its weight of carbon, and the acetit only 13. There is therefore more carbon in the acetous than in the acetic acid. Similar phenomena take place in the distillation of the acetat of copper; the acetous acid is deprived of its superabundant carbon; one part of this carbon combines with the oxygen of the copper, and forms the carbonic acid, which is disengaged, while the other remains in combination with the oxyd itself. The acetous acid deprived in this manner of its carbon, passes over in the state of acetic acid. Metallic oxyds, and some acids, seem to be the only substances capable of effecting this decomposition.

From these, and other experiments, Chaptal concludes; 1. That the difference between the acetous and acetic acids depends on the different proportions of carbon which they contain. 2. That the acid is in the state of acetous acid in metallic salts; and, 3. That it passes to the state of the acetic, only by being deprived of a portion of its carbon. *An. de Chem.* Tom. XXVIII. p. 113.

A CHAPTER XXV.

CONCERNING THE PUTRID FERMENTATION OF VEGETABLES.

ALL the vegetable substances, which have passed the vinous and acid fermentation, are susceptible of a third intestine commotion, by which they are changed; this is called the putrid fermentation. Stahl, and several other chemists, have thought, that this kind of fermentation is merely a consequence of the two preceding, or rather that these three phenomena depend on a single process, or motion, which tends to destroy the texture of solid substances, and to change the properties of fluids. It is true, in fact, that if certain vegetable substances be left to themselves, they pass through the three fermentations successively, and without interruption. For example; all saccharine matters, dissolved in a certain quantity of water, and exposed to a degree of heat of about 60 or 80 degrees, afford, first wine, afterwards vinegar, and at last the acid character is destroyed; they putrify, lose all their volatile principles, and become dry, insipid, and earthy. But it must be observed, that a great number of vegetable substances do not pass through these three kinds of fermentation, at least as far as sense can distinguish. Insipid mucilages, and solutions of gum in water, become sour, without exhibiting any appearance of wine; and the glutinous matter appears to pass immediately to putrefaction, without previously becoming acid. It therefore appears, that though these three fermentations succeed each other in many of the vegetable principles, there are nevertheless many others which are capable of the two last, without the foregoing, or even of putrefying, without exhibiting previous signs of acidity. These last participate of the nature of animal substances, and afford ammoniac by the action of heat, and azotic gas by the nitric acid. It appears to be from this character, that the vegeto-animal substances putrify so readily.

The intestine motion which changes the nature of vegetable matters, and reduces them to their elements, requires the following conditions. Humidity, or the presence of water, is one of the most necessary; dry and solid vegetables, such as

wood, are not at all changed, while they remain in that state ; but if they be moistened, and their fibres separated, the intestine motion soon commences : water, therefore, appears to be one of the causes of putrefaction ; and we shall see, in the animal kingdom, that the decomposition of this liquid appears to produce fermentation. Heat is not less necessary. Cold, or the temperature of ice, not only opposes this spontaneous destruction, but retards its progress, and in some measure restores the former state of substances which have begun to change. The degree of heat necessary to putrefaction, is much less than that which maintains the vinous and acid fermentation, since it requires no more than about 45 degrees of temperature ; but a stronger degree of heat is more favourable to this process, provided it be not so strong as to volatilize all the humidity, and entirely to dry the substances which it putrefies. Access of air is a circumstance which singularly promotes putrefaction, since vegetable substances are very well preserved in a vacuum. This preservation, however, has its limits ; and the contact of air does not appear to be indispensable for carrying on putrefaction, like the two conditions before mentioned.

The putrefaction of vegetables has its peculiar phenomena. Vegetable fluids, which putrify, become turbid, lose their colour, and deposit different sediments ; bubbles rise to the surface, and mouldiness appears at the beginning. Vegetable matters, simply moistened, and soft, exhibit the same phenomena ; the commotion is never so great as in the vinous and acetous fermentations. The bulk of the matter which putrifies does not appear to increase, neither does its temperature rise ; but the most important phenomena is the change of smell, and the volatilization of an acrid penetrating urinous principle, similar to ammoniac, and which, on examination, is found to be that substance. Hence the putrefactive fermentation has been distinguished by the name of the alkaline fermentation, and the ammoniac has been considered as its product. The penetrating smell flies off by degrees, and is succeeded by a nauseous, faint smell, not easily described. The decomposition is then at its height ; the putrefying vegetable matter is then very soft, or fluid, like a

syrup; it experiences a great number of successive modifications in the odorant principle which exhales. Lastly, It dries, its disagreeable smell is dissipated by degrees, and nothing remains but a blackish, and as it were coaly residue, known by the name of earth, *humus vegetabilis*, in which nothing is found but certain saline and earthy substances. Such is the order of the phenomena observed in the spontaneous decomposition of vegetables which putrefy: but this decomposition, carried to that point in which bodies are reduced to their saline or earthy skeleton, requires a very long time; and it may even be added, that it has not yet been properly observed by any person. This reproach which is cast on chemists and philosophers for their inattention to animal matters, is much more deserved with regard to vegetable substances. No philosopher has yet undertaken to observe the complete putrefaction of these last, though many have begun to describe the phenomena which take place in that of animal matters. We may therefore conclude the history of the spontaneous and natural analysis of vegetables, by adding, simply, 1. That the short account we have given shows, that vegetable putrefaction attenuates, volatilizes, and destroys their humours, and reduces them to the earthy state. 2. That nothing is yet certainly known concerning the phenomena and limits of this kind of putrefaction, which requires to be properly distinguished from that of animal matters. 3. Lastly, As this fermentation is much more evident, and has been better observed in the fluids and solids of animal substances, the larger detail we shall enter into, respecting these last, will complete our historical sketch of the known facts relating to putrefaction.

PART IV.

THE ANIMAL KINGDOM.

CHAPTER I.

CONCERNING THE CHEMICAL ANALYSIS OF ANIMAL SUBSTANCES IN GENERAL *.

THE analysis of animal substances is a part of chemistry, which is the most difficult, and the least advanced of any. The ancient chemists contented themselves with distilling these substances by a naked fire; an operation which is now known to alter, and entirely change bodies of so compounded a nature as the solids and fluids of animals. Some of the fluids of the human frame, and of certain quadrupeds, only have been subjected to this analysis.

Many causes oppose the advancement of this branch of chemistry; the difficulty and unpleasantness of these experiments, the small number of expedients for the treatment of animal matters, without changing them very much, the impossibility of finding the most remote synthetical method of reproducing these matters, and more particularly the uninteresting nature of these researches to chemists who are not physicians, are the principal motives which have hitherto impeded the progress of science respecting them. Nevertheless, the researches of cer-

* In the First and Second Editions of this Work the animal kingdom commenced with a brief account of the nature of animals, of their distinctive characters, of the methods employed in natural history to distinguish, and of the physiology of animals. The new arrangement of the volumes, and the little connection between the descriptions of animals and animal chemistry, has induced me to remove that part into the fifth volume.

tain modern philosophers, especially Rouelle, Macquer, Bucquet, Poulletier de la Salle, Berthollet, Proust, Scheele, and Bergman, have opened a new path, and show that the art of healing may receive the greatest advantages from inquiries of this nature.

The bodies of the principal animals, such as man and quadrupeds, to which our attention is particularly directed, are formed of fluids and solids. The fluids of animals are distinguished into three classes, relative to their uses. The first class contains the recrementitial humours, designed to nourish and support certain organs. The second comprehends the excrementitial humours which are excluded out of the body, by certain emunctories, as useless, and capable of producing noxious effects, if retained too long. In the third are ranked, such as are of the nature of the two preceding, being partly recrementitial, and partly excrementitial; the former are the blood, the lymph, the jelly or gelatin, the fibrous or glutinous part, the fat, the marrow, the matter of internal perspiration, and the osseous juice; the latter comprehends the fluid of insensible transpiration, the sweat, the mucus of the nostrils, the cerumen of the ears, the gummy matter of the eyes, the urine, and the fæces. The last are the saliva, the tears, the bile, the pancreatic juice, the gastric and intestinal juices, milk, and the seminal liquor. We cannot examine all these fluids in the order we have enumerated them; 1. Because these are very little known; 2. Because it is indispensably necessary to treat of those, in the first place, whose analysis is the most advanced.

The solids of animals, which form the parenchyma of their different organs, may be divided into three classes; the first containing soft and white parts, as the laminæ of the cellular tissue, the membranes, the membranous viscera, the aponeuroses, the ligaments, the tendons, and the skin. The soft and red parts form a second class, very distinct from the first; such, in particular are the muscles, and a part of those organs which contain muscular fibres, such as the stomach, the intestines, the bladder, the matrix, &c. Lastly, The third class comprehends the bony solids.

The animal analysis is at present very different from that formerly used. The decomposition by fire is now no longer prac-

tified, and animal matters are treated with re-agents, more especially acids, alkalis, alcohol, &c. The different fluids, mixed with each other, or contained in the vesicles of the different parts, are separated by repose, by decantation, by filtration, or by expression. The action of these substances on colouring matters is examined, as well as the several changes they undergo at different temperatures. By careful evaporation of animal liquors, the different salts they contain are separated without alteration.

By these methods of analysis, modern chemists have made many important discoveries. Scheele has discovered several acids different from all those before known. Berthollet has ascertained the existence of disengaged phosphoric acid in urine, and in sweat; he has likewise found a very considerable quantity of azot in animal matters. This last discovery is one of the most important parts of the animal analysis: the presence of azot in these substances, and especially in the fibrous parts, explains the difference which exists between them and vegetable matters. To obtain this elastic fluid, or azotic gas, muscular flesh must be treated with the nitric acid; a considerable quantity is disengaged, even without the assistance of external heat. This gas passes before the nitrous gas, and the receiving vessels must be changed as soon as the latter begins to appear.

By this discovery, Berthollet explains the formation of ammoniac, afforded by animal substances, subjected to the action of fire, and also the production and disengagement of this salt by putrefaction; together with the relation or resemblance of these substances with vegetable matters, which putrefy, and afford ammoniac by distillation. It appears, in fact, that this alkali is formed, in both cases, by the combination of hydrogen with azot. I cannot do better than quote, in this place, the words of Berthollet on the general nature of animal substances, in a memoir read at a public meeting of the Faculty of Medicine, and inserted in the *Journal de Physique*, Volume XXVIII. page 272.

“ Organized bodies are principally composed of two substances, which have very evident distinctive characters; the one affords acid, when decomposed by the action of fire, and the other volatile alkali; the one forms ardent spirit, by
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“ fermentation, the other putrefies immediately, and affords
“ volatile alkali ; the one, by calcination, affords a coal, which
“ burns readily, the other is reduced into a coal of difficult
“ combustion : lastly, the former compose the greatest part of
“ vegetable, and the latter of animal substances ; whence they
“ are distinguished by the two denominations.

“ Bergman formed, by means of sugar and the nitrous acid,
“ an acid which he called the *saccharine acid*, and which posses-
“ ses remarkable properties. I applied this kind of analysis
“ by the nitrous acid to animal substances, and I found that
“ they all afforded a greater or less quantity of saccharine
“ acid, but always accompanied with a peculiar oil. I ob-
“ served that no ammoniacal salt was obtained, but that a re-
“ sidue was afforded, which is not found in vegetables. From
“ these first experiments I concluded (*Memoires de l'Acade-*
“ *mie*, 1780), that animal substances contained a substance a-
“ nalogous to sugar, united to an oil, which I considered as
“ peculiar to animal substances. My experiments likewise in-
“ formed me, that the volatile alkali did not exist in animal
“ substances, but that it arose from a combination formed ei-
“ ther by the action of heat, or the influence of putrefaction ;
“ and lastly, the residue concerning which I did not explain
“ myself in that memoir, contains phosphoric acid in excess,
“ combined with calcareous earth.

“ I afterwards examined the action of lime and metallic
“ salts on animal substances, and proved, that this action in
“ which their causticity consists, is a consequence of the chemi-
“ cal affinities of the metallic calces, which tend with various
“ degrees of force to become revived ; so that those which are
“ very easily revived, such as the calces of silver and of mer-
“ cury, have a strong degree of causticity, and form very cau-
“ stic salts. Hence it follows, by applying the modern disco-
“ veries of philosophers to the theory I have given, that it is
“ the air combined in metallic calces, and deprived of the prin-
“ ciple of elasticity, which tends to unite with a principle of
“ animal substances, and this principle appears to me to be
“ the oil they contain ; but the causticity of alkalis cannot be
“ attributed to the same cause, but must be the effect of ano-
“ ther affinity. I have proved, in the *Memoirs of the Acade-*

“ my for the year 1782, that the caustic alkali dissolved animal substances without disuniting their principles. I have shown the properties of this combination, and have availed myself of it to unite the animal substances with different metallic calces; several combinations were produced, which were before unknown to chemists; but the caustic alkali treated in the same manner with vegetable substances, formed no combination.”

“ By pursuing my inquiries, I have succeeded in determining the principles of the volatile alkali. I have shown, that the volatile alkali is a combination of detonating inflammable gas, or, to speak more accurately, of the inflammable gas of water and phlogificated air, or mephitic: so that the inflammable gas forms nearly the sixth part of the weight, or two thirds of the volume of the volatile alkali. I have since determined how the volatile alkali is produced by putrefaction, or by the action of fire. All matters which have the character of animal substances contain mephitic, which may be abundantly separated by means of the nitrous acid. It must necessarily happen, therefore, when these substances are distilled, that their mephitic must pass into some combination, or that it will be found among the aeriform products; but it is not found in these last, as I have ascertained, by detonating the inflammable gas obtained by this method in the eudiometer of Volta, and comparing it with the inflammable gas obtained by the distillation of charcoal, and that of vegetable substances; and there is nothing among the other products of the distillation but the volatile alkali, which can have received it into its composition. Consequently, whenever volatile alkali is formed, the mephitic of the animal substances combines with the inflammable gas, which is separated from the oil, or most probably with that which arises from the decomposition of the water, whose vital air at the same time combines with the charcoal to form fixed air. In putrefaction, the inflammable gas combines with the mephitic; whereas in the spirituous fermentation, the same gas combines with a vegetable oil and sugar, to form spirit of wine, in which I have

“ found and separated these substances, by means of the dephlogisticated marine acid.

“ From these several observations it follows, that animal substances are much more compounded than substances which are purely vegetable. They contain a matter analogous to sugar, a peculiar oil, phosphoric acid combined with a small quantity of calcareous earth, mephitic, and, very probably, fixed air. It is the phosphoric acid which exists in the coal of animal substances, combined with a portion of the true charcoal, of the oil, and with earth, that appears to me to constitute the difference observed to exist between the coals of animal substances and those of vegetables.”

Such is the clear and perspicuous manner in which Berthollet conceives and explains the general nature of animal substances. When these accurate results are compared with the vague notions hitherto exhibited respecting the difference between vegetable and animal matters, we are astonished at the progress which chemistry has made of late years, by the researches of the Swedish and French chemists. There is every reason to think, that a connected series of inquiries into the nature of animal matters, according to the plan sketched out by the most celebrated chemists from the time of Margraaff and Rouelle to the present, would afford many valuable particulars of information respecting their formation, alterations, and destruction; and would be more particularly useful in the art of medicine. The application of the discoveries already made, which we shall exhibit in the following chapters, will place this assertion beyond all doubt ^a.

NOTES ON CHAPTER I.

^a ANIMAL substances are composed chiefly of azot, carbon, hydrogen, and oxygen. They also contain a variety of saline, earthy, and metallic substances. Some of them are found so invariably present in animal matter, that they may be regarded as essential to its composition. Of this kind are phosphoric acid, lime, and perhaps soda.

Azot. Nitric acid separates azotic gas from all animal substances. The acid is not decomposed unless the mixture be placed in a high temperature. The azotic gas carries with it a little carbon in solution. There are great differences among animal substances, in the quantity of azot which they afford, and in their readiness to part with it. The presence of azot in animal matter was detected by Berthollet. *Journ. Phys.* XXIX. 389, 395. *Mem. Acad. Sc.* 1785. 331, 349. The subject has been prosecuted by Fourcroy, *Ann. Chem.* I. 40, 46. Some objections of Mr. Keir are very satisfactorily answered by Berthollet. *Ann. Chem.*

It had been long known, that the distillation of animal substances afforded ammoniac; and this product had been regarded by many chemists as the characteristic distinction between animal and vegetable matter; but it was reserved for Berthollet to prove, that the elements only of this ammoniac exist in animal matter; and that it is formed during animal putrefaction, or distillation, by the union of azot and hydrogen. It was afterwards shown by Fourcroy, that the quantity of ammoniac obtained from different animal substances corresponds with the quantity of azot which they contain; and it appears from the interesting observations of Vauquelin, that the hydrogen also of the ammoniac is derived from the decomposition of animal matter.

Concentrated sulphuric acid decomposes animal matter, and converts one part of it into water, another part of it into acetic acid, and a third part into ammoniac; a carbonaceous magma, or carbonaceous flocculi being at the same time precipitated. No gas is disengaged during this experiment. The acid is not decomposed, but combines with the water and ammoniac. Greater effects take place when heat is used. *Ann. Chem.* XXIII. 199. Berthollet had long before this obtained ammoniacal salts from animal matter by dissolving it in sulphuric or muriatic acid, and afterwards exposing the mixture to the action of fire. *Ann. Chem.* X. 133.

Caustic alkalis, in dissolving animal matter, convert part of it into ammoniac, especially when their action is aided by fire. This fact escaped the notice of Berthollet. *Mem. Acad. Sc.* 1782. 616. It is slightly mentioned by Fourcroy. *Ann. Chem.* VII. 174.

Caustic lime decomposes animal matter, and changes part of it into ammoniac. Berthollet ascribes the causticity of lime to its affinity for water. *Id.* 1782.

Carbon. Carbon exists in abundance in animal matter; as appears from the carbonaceous residue of animal distillation, and from the quantity of carbonic acid, and of carbonated hydrogen gas which are obtained during the same process.

Hydrogen. The presence of hydrogen in animal matter is most decisively proved, by the simultaneous formation of water and ammoniac, in dry animal substances exposed to the action of concentrated sulphuric acid. Empyreumatic animal-oil is another proof of the existence of hydrogen in animal matter. The carbonated hydrogen gas, obtained from animal distillation, derives its hydrogen in part from the decomposition of water. *Mem. Acad. Sc.* 1786. 590.

Oxygen. That animal matter contains oxygen, besides the oxygen existing in it in the state of water, appears from the water and acetic acid, into which part of it is converted, by the disposing affinity of the concentrated sulphuric acid. The formation of carbonic acid, during animal distillation, is an ambiguous phenomenon; since it is always accompanied by the disengagement of carbonated hydrogen gas.

CHAPTER II.

CONCERNING THE BLOOD.

THE blood is the most important, the most compounded, and the most impenetrable of the recrementitious humours. We shall treat of it in the first place, because, according to the doctrine of the greatest physicians, it is the focus and source of all the other animal floods. Many physicians, and particularly Bordeu, considered it as a kind of fluid flesh, and as a compound of all the animal humours. This opinion is not entirely proved, though it is very probable.

The blood is a fluid of a beautiful red colour, and an unctuous fat consistence, as it were saponaceous, of an insipid and rather saline taste, which is contained in the heart, the arteries, and the veins. This fluid differs greatly, according to the regions through which it passes; it is not, for example, the same in the arteries, and in the veins, in the stomach, and in the region of the liver, in the muscles, and in the glands, &c. This fact has not been sufficiently attended to by chemists.

When we consider the blood, with respect to the whole animal kingdom, we may observe that it varies remarkably in different animals, with respect to colour, consistence, smell, and more especially temperature. This last property is the most important, and appears to depend on the circulation and the respiration. The blood of men, quadrupeds, and birds, is hotter than that of the medium they inhabit; they are therefore called *animals with warm blood*. In fishes and reptiles it is nearly of the temperature of the medium they inhabit; for which reason they are called *animals with cold blood*. It is probable, that differences equally considerable would be found to obtain in all the other properties of this fluid, and especially the chemical qualities or characters, if the blood of all animals were properly examined.

The blood of man, to which our attention is particularly directed, differs according to the age, sex, temperament, and state of health of the individual: in infancy, in the female sex,

and in consumptive persons, it is paler, and thinner; in robust and healthy men it is thicker, of a deeper colour, almost black, and of a much more saline taste.

Before we proceed to the analysis of blood, it will be proper to speak of its physical properties; namely, its colour, temperature, taste, smell, and peculiar consistence, which we have already mentioned. The microscope discovers a great number of globules, which, when broken, according to Leuwenhoek and Boerhaave, by passing through the smaller passages, lose their red colour, become yellow, and afterwards white; so that, according to the physician of Leyden, a red globule is an assemblage of many smaller white globules, and owes its colour to its aggregation only^a. The blood likewise presents remarkable physical properties: while hot, and in motion, it remains constantly fluid and red; when it cools at rest it takes the form of a solid mass, which gradually and spontaneously separates into two parts; the one red, which floats above, whose colour becomes deeper, and which remains concrete, till it is altered by putrefaction, is called the *coagulum*; the other, which occupies the lower part of the vessel, is of a yellow greenish colour, and adhesive; it is called *serum*, or lymph. This coagulation and spontaneous separation of the two parts of the blood takes place at the last moments of the life of the animal, and produces those concrete substances which are found in the heart and the large vessels, and have been falsely taken for polypi. Blood exposed to a gentle heat long continued, undergoes the putrid fermentation. By distillation on the water-bath, it affords phlegm of a faint smell, which is neither acid nor alkaline, but readily putrefies by virtue of an animal substance it holds in solution^b. Blood heated more strongly coagulates, and gradually dries, as De Haen has discovered, losing seven-eighths of its weight, and effervescing with acids. By a well managed fire, it hardens into a kind of corneous substance. If dried blood be exposed to the air, it slightly attracts humidity, and at the end of some months a saline efflorescence is formed, which Rouelle found to be carbonat of soda. By distillation with a naked fire, it affords a saline phlegm; that is, a phlegm holding in solution ammoniacal salt superaturated with ammoniac. The nature of this empyreumatic

acid, first perceived by Wiewfens, and which has excited such disputes among physiologists, has not yet been properly examined. A light oil afterwards comes over; next a coloured and ponderous oil, and ammoniacal carbonat, contaminated by the thick oil; a spongy coal remains in the retort, which is very difficult to incinerate, and contains muriat of soda, carbonat of soda, oxyd of iron, and a substance apparently earthy, which appears to be calcareous phosphat^c. In burning blood in a crucible, several substances are observed to be disengaged in the following order: 1. Water, and a small quantity of ammoniac. 2. Oil, and carbonat of ammoniac, which form a yellowish vapour thicker than the preceding. 3. Prussic acid, easily known by the fetid odour of peach blossoms. 4. Phosphoric acid, which is formed by the combustion of the phosphorus, and which is disengaged only when the blood is reduced to the state of a charcoal. 5. Carbonat of soda, which is raised by a great heat. 6. When blood is heated in this manner, there remains in the retort only a blackish oxyd of iron, granular and crystallized, which is mixed with phosphat of lime^d.

Blood united to alkalis becomes more fluid by standing. Acids immediately coagulate it, and change its colour^e. By filtration, and evaporating of the filtrated liquor to dryness by a gentle fire, and subsequent lixiviation of this residual matter, such neutral salts are obtained, as soda forms with each acid; any of which may be indiscriminately used. Alcohol coagulates blood. If blood mixed with a fourth of its weight of water be coagulated by heat, and the supernatant liquid portion evaporated, a yellow brown matter is obtained, which is easily known to be a true bile. This discovery, which was made at the Lyceum in 1790, confirms the opinion of the ancients, who admitted the existence of bile in the blood^f.

Experiments made on blood in its original state, do not show the nature of the substances which compose this fluid; but the spontaneous decomposition of blood, and the separation of its two parts, the clot and the serum, afford a method of performing this by examining each substance in particular. Till within a few years, the chemical analysis of blood was confined to what has been related in the foregoing pages. Meng-

hini, Rouelle the younger, and Bucquet, have examined this fluid in a very different manner. The two last chemists have made experiments with this substance, which show how nearly the analysis of animal matters is capable of being brought to perfection by following their steps. From the researches of these learned men, we shall proceed to consider the properties of each of the substances which compose blood.

The serum, far from being pure water, is a peculiar matter of great importance to be considered, and to which we give the name of the albuminous fluid. It is of a yellowish white, inclining to green; its taste is dull and saline; its consistence unctuous and adhesive. When exposed to heat, it coagulates and hardens long before it boils. It converts syrup of violets to a green. When distilled on the water bath, it affords a mild and insipid phlegm, neither acid nor alkaline, but subject to putrefaction: the matter in the retort is then dry, hard, and transparent, like horn, and no longer soluble in water^e; but by a strong heat it affords an alkaline phlegm, much ammoniacal carbonat, and a very fetid thick oil. All these products in general have a peculiar fetid smell. The coal of serum distilled by a naked fire, almost entirely fills the retort. It is so difficult to incinerate, that it requires to be kept red hot for several hours, with a large surface exposed to the air, before it can be reduced to ashes. The ashes are of a blackish grey, and contain muriat and carbonat of soda, and calcareous phosphat.

Serum exposed for a certain time to a warm temperature in an open vessel, passes quickly to putrefaction, and then affords much ammoniacal carbonat, accompanied by an oil of an abominable smell. It putrefies so rapidly, that Bucquet could not decide whether it passes to acidity before it becomes alkaline^d. This fluid unites with water in all proportions, and then loses its consistence, its taste, and its greenish colour; the mixture must be agitated, in order to promote the union of the two fluids, which are kept apart by their different densities. Serum poured into boiling water, is immediately almost entirely coagulated. A portion of this fluid forms with water a kind of white, opaque, and milky fluid, which, according to Bucquet, has all the characters of milk; that is to say, it affords cream, coagulates by heat, by acids, and by alcohol. The serum, or the albuminous part which it contains, possesses the property

of fixing, and of rendering solid by heat, two or three times its weight of water. When from seven to eight parts of water are added to the serum, the albumen does not become concrete by heatⁱ. The cause of the singular property which the blood possesses of coagulating by heat, escaped the researches of philosophers. I am of opinion that it is owing to the combination of oxygen, assisted by heat, as happens in all other substances, since a metallic oxyd, mixed with the serum, thickens it while it passes to the metallic state. Besides every fact relative to the coagulation of the albuminous matter, seems to show, that the more air it contains the more it absorbs; and the more speedily it concretes by fire, the more solid it becomes by that agent^k.

Alkalis, added to serum, render it more fluid by a kind of solution. Acids change it in an opposite manner, by giving it consistence, and by coagulating it. This last mixture being filtrated, and the fluid evaporated, the neutral salt, which the acid made use of, forms with soda, is obtained; which proves, that this last salt existed in a disengaged state, and possessed all its properties in the serum. The coagulation formed in this liquor, by the addition of an acid, dissolves very quickly in ammoniac, which is the true solvent of the albuminous part; but it is not at all soluble in pure water^l. Acids precipitate this substance united to ammoniac. The coagulation distilled by a naked fire affords the same products as dried serum, and its coal contains much carbonat of soda; which proves, according to Bucquet, that there is a portion of this salt so intimately combined in the serum, as not to be saturated by the coagulating acid.

The serum, in its dense state, affords azotic gas by the action of the nitric acid on the application of a gentle heat. If the heat be raised, prussic acid gas and nitrous gas are disengaged from the mixture; the residue affords the oxalic acid, and likewise a small quantity of metallic acid. The formation and disengagement of the prussic acid by serum, and the nitric acid, is a discovery which affords a more simple and economical process, than that of Scheele, for obtaining this acid in a pure state*.

Serum does not decompose the calcareous and aluminous

neutral salts ; but it decomposes metallic salts very readily. It is coagulable by alcohol, and this coagulum differs greatly from that which is formed by acids, more particularly in its solubility in water, as Bucquet has discovered. This liquid therefore appears, from these experiments, to be an animal mucilage composed of water, acidifiable oily bases, muriat and carbonat of soda, and calcareous phosphat : this last appears to produce the rose-coloured precipitate, which I have obtained by pouring the nitric solution of mercury into serum. Though the liquid be scarcely coloured, the addition of nitric acid, and more especially of mercurial nitrat, produces a rose or light flesh colour, which I have frequently observed in many other animal liquors. The most singular property of this mucilage, which deserves the attention of physicians, is its becoming concrete by the action of fire, and of acids. Scheele thinks that this phenomenon arises from the combination of heat. Its true cause has been already mentioned ^m.

The clot of blood, exposed to the heat of a water-bath, affords an insipid water, and becomes dry and brittle. By distillation it affords an alkaline phlegm, a thick oil of a fetid and empyreumatic smell, and much ammoniacal carbonat. Its residue is a spongy coal of a brilliant and metallic aspect, difficult to incinerate, and which, when heated with the sulphuric acid, affords sulphats of soda and of iron. After these operations, a mixture of calcareous phosphat and coaly matter remains. The clot of blood putrefies very quickly in warm air. When washed with water, it is separated into two very distinct substances, one of which is dissolved, gives the fluid a red colour, and the solution, when heated with different menstrua, exhibits all the characters of serum ; but it contains a much greater quantity of iron, which may be obtained by incineration of the coal, and subsequent washing, to separate the saline matters. The residue of this washing is in the state of an oxyd of iron, of a beautiful colour, and usually attracted by the magnet. The colour of blood is attributed to this metal. Iron has been obtained from blood in considerable quantities, by Menghini, Rouelle, and Bucquet ⁿ.

The clot, after having been washed, and deprived of all its red serum, appears to consist of a white fibrous matter, which remains to be examined.

The fibrous part of the blood is white, colourless, and insipid, after it has been well washed. By distillation on the water-bath, it affords a tasteless phlegm of a faint smell, and capable of putrefaction. The most gentle heat singularly hardens the fibrous matter: when suddenly exposed to a strong heat, it shrinks up like parchment. By distillation in a retort, it affords an ammoniacal phlegm, a ponderous, thick, and very fetid oil, with much ammoniacal carbonat contaminated by a portion of oil. Its coal is not bulky, but compact and heavy, and is less difficult to incinerate than that of the serum. Its ashes are very white, and contain neither saline matter nor iron; which doubtless were carried off by the previous washing: the appearance of these ashes is earthy, and they seem to consist of calcareous phosphat.

The fibrous part in the blood putrefies very quickly, and with great facility; when exposed to a hot and moist air, it swells, and affords much ammoniac. It is not soluble in water; when boiled with that fluid it hardens and assumes a grey colour. Alkalis do not dissolve it^o; the most feeble acids combine with it. The nitric acid disengages much azotic gas, as Berthollet has observed; and we have discovered that it forms prussic acid, which is disengaged in the form of vapour; it afterwards dissolves it with effervescence, and disengagement of nitrous gas; when all this gas is disengaged, oily and saline flocks are observed in the residue, which float in a yellowish liquor; by evaporating this liquor, crystals of oxalic acid are obtained, and a considerable quantity of flocks, formed of a peculiar oil and calcareous phosphat is deposited. It appears that the hydrogen, carbon and azot, which constitutes the fibrous matter, are divided into different portions, to combine with the oxygen of the nitric acid; and that they form in this way the prussic and carbonic acids, which we distinguish in the gaseous state together, with the oxalic and malic acid, which are separated only by crystallization.

The fibrous matter is likewise soluble in the muriatic acid, which causes it to assume the form of a green gelly. The acid of vinegar dissolves it with the assistance of heat: water, and more particularly alkalis, precipitate the fibrous matter when dissolved in acids. This animal substance is decomposed

in these combinations; and when separated from the acids by any method, it no longer presents the same properties. The neutral salts, and other mineral substances, do not act upon it. It unites to the albuminous substance, especially that which is coloured, to form the clot. This last, like the fibrous part, is totally soluble in acids; doubtless, on account of the combination of this matter with the red serum. Hence we see, that the fibrous part differs greatly from the albuminous matter. It is a substance more perfectly animalized than this last; a kind of animal gluten, which greatly resembles that of flour, and which more especially possesses the remarkable property of becoming concrete, by cooling and rest^p. It cannot be doubted, but that this matter, which has not hitherto been distinctly observed by physiological and pathological physicians, is of the greatest consequence in the animal economy. I have long since observed, that it is deposited in the muscles, constituting the fibrous base of these organs, and that it forms the substance which is most eminently irritable^q. Whence I have inferred, that it is of consequence to pay a greater attention to this substance than has hitherto been done; and to consider it as capable, by its abundance or deviation, of causing peculiar disorders. And I have exhibited the proofs of these useful medical considerations in a Memoir, which is inserted in the volume of the Royal Society of Medicine for the year 1783, &c. It seems to be in the fibrous substance that the particular acid exists, which the blood affords by distillation, and which Chauffier obtained by the action of alcohol. For this reason I have proposed to call it the *cruoric* acid, if it should hereafter be found to be a peculiar acid.

Notwithstanding these researches into the nature of blood, much remains to be done before its chemical properties will be perfectly known. The intimate difference between the serum and the fibrous part is yet unknown: neither has blood been yet examined in all its states; especially in the different disorders which considerably alter this fluid; as, for example, in strong inflammations, in the chlorosis, scorbutic disorders, &c. Physicians judge of these alterations merely by the external appearance, and it is much to be wished that their nature were better ascertained by accurate analysis. The blood of the hu-

man fœtus differs in three very remarkable circumstances from that of the adult; it contains no fibrous matter, properly so called, but a kind of gelatin; it does not assume a florid colour by the contact of air, and we have not found in it any traces of the phosphoric acid. *Mem. Ac. Sc.* 1789, 307.

Rouelle has examined the blood of several quadrupeds, such as the ox, the horse, the calf, the sheep, the hog, the ass, and the goat; he obtained the same products as from the human blood, but in different proportions. *Journ. Med.* 1776.

NOTES ON CHAPTER II.

BLOOD.

^aTHE colour of the red particles is not owing to their aggregation; for they communicate their colour to the water which dissolves them: nor are they formed of smaller spherules, as was supposed by the Boerhaavian school. Microscopical observers are not agreed with respect to their precise figure. According to Hewson, they consist of an internal spherical nucleus, enclosed within a flat circular vesicle of a red colour. Hunter, Blumenbach, and Cavallo, consider them to be spherical. *Hewson, Pb. Tr.* LXIII. 303, 320. *Hunter on the Blood*, 41. *Blumenbach, Inst. Physiol.* 12. *Cavallo on the Medicinal Properties of Facitious Airs, Appendix.*

^bThe odour of this phlegm is the same with that of the vapour, or *halitus*, which makes its escape from recent blood, when exposed to the air.

The odorous principle of blood is soluble in water, in air, and in alcohol. By passing the air, in which it is dissolved, through water, it leaves the air, and is dissolved by the water. The residuary air is found not to differ from common atmospheric air.

Air, impregnated with the halitus of blood, did not precipitate lime water, nor detonate with a lighted candle. When recent, it appeared in eudiometrical essays to be as good as common air; but, after having been kept for some time in a warm temperature, its smell had become disagreeable, though not in the least ammoniacal, and less of it was absorbed by nitrous gas. These changes did not take place in a low temperature. *Parmentier and Deyeux. Journ. de Phys.* 1794. 384, 387.

Plene had supposed, that the halitus of blood contains carbonated hydrogen gas. *Hygrologia Corp. Human.* 43.

^cWhen dried blood is distilled by itself, there passes first into the receiver a transparent liquid, holding prussic acid in solution. *Fourcroy. Mem. Ac. Sc.* 1789. 302.

^d9216 grains of blood dried in a water bath, left 181 grains of fixed residue, after combustion in an open crucible. The greater part of this residue consisted of

a black oxyd of iron, resembling that of the isle of Elba, mixed with a little of the red oxyd of iron. It also contained a small quantity of the muriat of soda; but not a particle of foda, which must therefore have been dissipated by the force of the fire. *Fourcroy, Mem. Ac. Sc. 1789. 300.*

^e Haffenratz poured oxygenated muriatic acid into venous blood. The blood was instantly decomposed, and acquired a very dark and almost black colour. Common muriatic acid of the same strength occasioned no change of colour in the blood; but, when more concentrated, it precipitated a number of brown floculi. *Ann. Chem. IX. 268.*

Nitric acid gives a dark green colour to the blood; sulphuric acid, a dark brown.

^f This experiment is related by Fourcroy, *Mem. Ac. Sc. 1789. 302. Ann. Chem. VII. 314.* Parmentier and Deyeux repeated the experiment; but neither from the uncoagulated, nor from the coagulated part of the blood, could they procure any substance resembling bile. *Journ. Phys. 1794. 388.*

^g We are told, that if serum be exposed to the temperature of 100° , it is gradually inspissated into a brownish solid mass, which may be dissolved again in water. *Hewson, Exp. Inquiry, I. 137.*

^h Brugmans found, that serum, in the first stage of its spontaneous decomposition, became acid, and gave a red tinge to the infusion of violets. This acescency was of longer duration in the serum of dropical patients, than in the serum of persons labouring under inflammatory fever. It also lasted longer in the pure gelatin of the serum, than in the serum itself. The pure albumen gave no marks of acidity during its putrefaction. *De Puogenia, 23, 29.* Berthollet has also found, that a liquid is separated from putrid flesh, containing ammoniac, in combination with an excess of acid. The acid appeared to him to be the zoonic, but the quantity of it was too small for accurate examination. *Ann. Chem. XXVI. 88.*

ⁱ But when the mixture is reduced by evaporation to less than the original quantity of serum, a firm, transparent pellicle, insoluble in water, forms on its surface. *Mem. Ac. Sc. 1789. 304.*

^k A small quantity of serum was mixed by Fourcroy with the red oxyd of mercury by potash. No immediate action followed; but, after remaining in contact for 12 hours, the oxyd had got a dark grey colour, and the serum was become thick and firm. *Mem. Ac. Sc. 1789. 305.* In repeating this experiment, with common red precipitate, I have observed, that the oxyd first acquires a yellow, and afterwards a dark grey colour. The serum is so completely coagulated, as to be insoluble in water.

Serum is still more speedily coagulated by the corrosive muriat of mercury; but it is not coagulated by the super-oxygenated muriat of potash, nor by the oxyd of arsenic, lead, or manganese. *Birkbeck. Tent. Inaug. de Sang. Edin. 1799, p. 19.*

Serum is coagulated at 167° , without the contact of atmospheric air. Carradori covered with olive oil the albumen of a new laid egg, and exposed it to the heat of boiling water. Coagulation took place as in the open air, and no elastic gas escaped through the oil. *Ann. Chem. XXIX. 38.* I have repeated this experiment with serum, and found that it was coagulated at the same temperature under oil, as when exposed freely to the air.

Fourcroy relates a curious experiment with respect to the coagulation of serum. He placed a thin glass vessel, containing serum, in a water bath; and observed, that a thermometer, immersed in the serum, rose to 212° , at the instant when the serum was coagulated. *Mem. Ac. Sc. 1789. 303.* I have often tried this experiment, but in no instance was there any sensible evolution of caloric accompanying the coagulation of the serum. Serum usually coagulates between 165° and 167° .

When placed in a water bath, it becomes muddy about 160° ; and its temperature continuing to rise, it is sometimes wholly coagulated exactly at 167° . No sudden increase of temperature follows. The thermometer, on the contrary, rises more slowly after the serum is coagulated, than before; a phenomenon which seems to indicate, that coagulated albumen is a worse conductor of caloric than liquid serum.

¹ In the common temperature of the atmosphere, albumen is dissolved very slowly by ammoniac. Several months were required, before a small quantity of coagulated albumen was completely dissolved in caustic ammoniac.

Albumen is very readily dissolved by potash in the common temperature of the atmosphere. During the dissolution ammoniacal vapours are disengaged, and a greyish black matter is precipitated, in which carbon preponderates.

Albumen is also dissolved by soda, without the assistance of heat, and ammoniacal vapours make their escape during the dissolution.

^m Fourcroy has forgot to mention the gelatin existing in the serum.

Coagulated serum has a greyish white colour, and resembles in smell, taste, and consistence, the boiled white of an egg. It contains a great many small cells filled with gas, the nature of which is unknown. When the coagulum is cut into small pieces, there flows from it a muddy liquid, termed the serosity. In order to separate the serosity from the coagulated albumen, it is proper, after dividing the coagulum into very minute pieces, to immerse it in boiling water, and filtre it through paper. The albumen remains on the filtering paper, and the liquid, which passes through the filtre, affords, by evaporation, a gelatinous liquid, which concretes upon cooling. *Brugmans de Puoquenja*, 26. *Fourcroy, Mem. Ac. Sc.* 1789. 304.

The animal matter procured by this process is called the *gelatin*. It is not pure, but combined with soda, and muriat of soda.

Gelatin, in its spontaneous decomposition, evolves an acid, which not only saturates the uncombined soda, but gives to the gelatin an acid character. This stage of decomposition is succeeded by the formation of ammoniac. *Brugmans*, 29.

Gelatin is precipitated from the serosity by alcohol, but on boiling the alcohol, the gelatin is redissolved. It appears, that, in a low temperature, alcohol has a greater affinity than gelatin for water; and that in a high temperature the affinities are reversed. The same occurs with the jelly extracted from the cellular substance.

Gelatin is also precipitated from the serosity, by the sulphuric, muriatic, and nitric acids, but not by the acetous.

Potash renders the serosity transparent, by dissolving the albuminous particles which render it muddy.

Goulard's extract forms with gelatin a copious dense precipitate. *Hunter on the Blood*, 35. The acetit of lead also precipitates gelatin. Neither of these metallic solutions occasions a precipitate in the jelly obtained from the cellular substance.

Tanin forms with gelatin a copious but incoherent precipitate. With the cellular jelly it forms a peculiar substance, which will be afterwards described.

ⁿ The transparent solution obtained by infusing crassamentum in water, loses its colour between 160° and 170° , and a number of light brown flakes form in it.

The infusion of nut-gall separates from it an incoherent precipitate of a white colour, tinged with red, but having no blue or purplish tint.

The Prussian alkali occasions in it no precipitation. *Well's, Ph. Tr.* 1797. Part II.

^o Fibrin is dissolved very readily by potash in soda, in the common temperature

of the atmosphere. Ammoniacal vapours are disengaged during the dissolution, and a black carbonaceous matter is precipitated.

Fibrin is scarcely acted on by ammoniac without the assistance of heat; but placed in a water bath at 170° , the ammoniac dissolves the fibrin rapidly.

Fibrin boiled with lime water is corrugated, and has its force of cohesion much impaired, but is not sensibly dissolved.

p Fibrin is coagulated between 114° and 120° . *Heavson, Exp. Ing. I. 31.* Albumen, between 165° and 167° .

Nitric acid separates a greater quantity of azotic gas from fibrin than from albumen. *Fourcroy, Ann. Chem. I. 40.*

Concentrated nitric acid dissolves fibrin in the temperature of 60° , and extricates from it a great quantity of gas. It acts very slowly on albumen without the assistance of a higher temperature, separates from it a small quantity of gas, and is unable to dissolve it completely. At 150° albumen is rapidly dissolved by nitric acid, much gas is extricated, a waxy matter is formed, and a substance resembling gelatin is very frequently precipitated. Fourcroy first succeeded in procuring gelatin from albumen by nitric acid. *Ann. Chem. III. 252.*

q Potash acts less powerfully in the common temperature of the atmosphere upon the muscular fibre, than upon fibrin, but extricates from it, as from other animal substances, ammoniacal vapours, and precipitates a considerable quantity of carbonaceous matter.

CHAPTER III.

CONCERNING MILK.

MILK is a recrementitial humour designed to nourish young animals in the early part of their life. It is of an opake white colour, a mild saccharine taste, and a slightly aromatic smell. Man, quadrupeds and cetaceous animals, are the only creatures which afford milk : All other animals are destitute of the organs which secrete this fluid. It has always been supposed that the milk is separated immediately by the mammary glands from the blood that passes through the numerous arteries with which they abound ; but the principles found in milk have not yet been shown to exist in the blood. Modern anatomy has taught us that the breasts are provided with a great number of lymphatic and absorbent vessels, placed in a fatty membrane ; the fluid they contain is probably one of the principal materials of milk.

Milk differs greatly in the several animals ; in the human species it is very sweet or saccharine ; the milk of the cow is mild, and its principles are well connected ; that of the goat and ass have a peculiar virtue, as they are often slightly astringent. The variable properties of milk depend usually on the food of the animal.

Cows milk, which is taken as an example of the analysis, because it is easily procured, is a compound of three different substances, serum, or whey, which is fluid and transparent ; butter and cheese, which are more consistent. These three parts are so mixed as to form a kind of animal emulsion.

Milk distilled by the heat of a water-bath, affords a tasteless phlegm of a faint smell, and capable of putrefaction. By a degree of heat somewhat stronger, it coagulates like the blood, according to the observation of Bucquet ; by agitation, and gradual drying, it forms a kind of saccharine extract, called *franchipane*. This extract, dissolved in water, constitutes the whey of Hoffman ; the extract distilled by a naked fire affords acid, fluid oil, concrete oil, and ammoniacal carbonat. Its coal contains a small quantity of carbonat of potash, muriat of potash, and calcareous phosphat^a.

Milk, when exposed to a hot temperature, is capable of undergoing the vinous fermentation, and forming a kind of wine; but it is necessary that the quantity should be large. The Tartars prepare a vinous liquor with mares milk ^b. Milk quickly becomes acid, and coagulates. The caseous part becomes solid, and the serum separates. By heating milk a little, it experiences a remarkable thickening, swells, and a pellicle is formed on its surface; which is renewed in proportion as it is removed, till the whole of the caseous part is separated. Parmentier and Deyeux have discovered that it is the caseous part which form these pellicles ^{*}.

Acids immediately produce the same effects on milk; they coagulate it, but alkalis, more especially ammoniac, re-dissolve this *coagulum* [†]. Boerhaave affirms, that milk, when boiled with *oil of tartar*, becomes first yellow, afterwards red, and of the colour of blood. He even thinks, that it is a similar combination, which causes the milk to be converted into true blood in the human body. Neutral salts, sugar and gum, likewise coagulate milk by the assistance of heat, according to the observation of Scheele ^c.

To prepare whey, milk is heated, and twelve or fifteen grains of rennet is added to every pint. This substance, formed by the mixture of milk, turned sour in the stomach of calves, and of the gastric juice, is a ferment which coagulates the caseous part. When the coagulation is made, the whey is strained from the curd. The flowers of the thistle, and of artichoke, act in the same manner as rennet upon milk. The *gallium*, though it was supposed to coagulate the milk, has been found by Deyeux and Parmentier, not to possess that property. The internal membrane of the stomach of calves, and of birds, dried and pulverized, produces the same effect upon milk; which proves that the coagulation is produced by the gastric juice, dried and contained in the pores of this membrane ^d.

Serum, or whey, prepared in this manner, is turbid; it may be clarified by white of egg, or cream of tartar. When the serum, or whey, is required to be very pure, for the purpose

^{*} Ann. de Chem. VI. 186.

[†] Journ. de Phys. XXXVII. 72.

of examining its nature, the acidulous tartaric of potash must not be added.

Whey has a mild taste. When prepared with new milk, it contains a saccharine essential salt, but it soon acquires an acid taste, by the establishment of the fermentation. This change is produced by the alteration of a mucilaginous principle, contained in the milk; and it is the development of this acid which occasions the spontaneous separation of the whey from the other substances contained in milk. It is therefore necessary to examine the acid, which is formed in milk, and constitutes fermented whey. It is a well known fact, that milk left exposed in a temperature of seventy or eighty degrees, experiences, in a few days, a fermentation which develops an acid, and separates the butter and cheese. The acid, formed by this fermentation, and which is as strong as it will be at the end of twelve or fifteen days, has been examined by Scheele, and is called the *lactic acid* *. The following is the process used by Scheele, to obtain it in a state of purity. After having attempted, in vain, to separate the acid by distillation from sour whey, by which he obtained only a small quantity of vinegar, he evaporated the whey to one-eighth, after having filtrated it, to separate all the caseous matter. From this he precipitated the animal earth, by lime water. He then diluted the fluid with three times its weight of water, and separated the lime by the oxalic acid; at the same time taking care that this last acid should not remain disengaged in the solution, which was easily ascertained and prevented, by the addition of successive small portions of lime-water. After evaporating the liquor to the consistence of honey, the sugar of milk, and several other foreign substances, were then separated, by the addition of alcohol, which easily dissolves the lactic acid. Lastly, The decanted solution being distilled, the alcohol passed over, and the pure lactic acid remained in the retort. Scheele has observed the following properties in this acid.

When strongly evaporated, it did not afford crystals, but attracted the humidity of the air: by distillation, it afforded an empyreumatic acid, resembling pyrotararous acid; a small

* Scheele's Essays, 270. Journ. de Phys. XXII. 170.

quantity of oil, and a mixture of carbonic acid gas, and of carbonated hydrogen gas.

With the three alkalis, and also with barytes and lime, it forms deliquescent salts. Its combination with magnesia crystallizes, but likewise attracts the moisture of the air. The greater part of these salts, or alkaline and earthy lactates, are soluble in alcohol. It does not at all attack cobalt, bismuth, antimony, mercury, silver or gold, even by the heat of ebullition. It dissolves zink and iron, producing hydrogen gas; the first of these salts, called the lactate of zink, crystallizes; the second, or the lactate of iron, forms a brown deliquescent mass. The lactic acid oxydates, and dissolves copper and lead. The lactic solution of the latter metal deposits a small quantity of sulphate of lead, which indicates the presence of a small quantity of sulphuric acid in this animal acid. Lastly, It decomposes the acetate of potash; a property, which, together with most of those here mentioned, denotes that the lactic acid differs from vinegar. Scheele adds, likewise, that a true vinegar may be obtained from milk, by mixing six spoonfuls of alcohol with three pints of milk, and suffering the mixture to ferment in a well-closed vessel. The gas, which is disengaged during the fermentation, must be suffered to escape, from time to time; and at the end of a month the milk is changed into good vinegar, which may be strained through a cloth, and preserved in bottles. This celebrated German chemist likewise adds, that milk, in a bottle whose neck is plunged in a vessel filled with the same liquor, and exposed to a heat somewhat stronger than that of summer, undergoes a fermentation which affords a large quantity of elastic fluid. This last fluid displaces the milk, and almost entirely empties the bottle, at the end of two days. The acid produced in this fermentation, which takes place without the contact of air, appears to receive its oxygen, or acidifying base of the air, from the decomposition of the water.

The serum of milk, or whey, made by means of rennet, and not yet become sour, holds in solution a certain quantity of a saline substance, known by the name of salt, or sugar of milk. Though Kempfer affirms that the Brachmans were acquainted with the process for preparing this salt, it appears that it was first mentioned by Fabricius Bartholet, or Bartholdi, an Italian

physician, in the year 1619. Etmuller, Testi, Werlofschnigg, Wallisnieri, Fickius, and Cartheuser, have successively spoken of this substance, and described the methods of obtaining it. Vulgamoz and Lichtenstein have very well described the method of obtaining this saline substance, which is prepared in large quantities in several parts of Switzerland. The whey obtained from skimmed milk, coagulated with rennet, is evaporated to the consistence of honey; after which it is put into moulds, and dried in the sun. This is the sugar of milk in cakes, and is dissolved in water, clarified with whites of eggs, evaporated to the consistence of syrup, and crystallized in the cold. By this treatment it affords white crystals in rhomboidal parallelepipedons; the mother water deposits yellow and brown crystals, which are purified by successive solutions. Lichtenstein has examined and analyzed the different sugars of milk, which are sold at various prices in Switzerland, and has more particularly distinguished, 1. The *sweet sugar of milk*, which is of a white colour, obtained from sweet and purified whey. 2. The *acescent sugar of milk*, obtained from sour whey. 3. The *sugar of milk rendered impure by fat substances*; which separate, according to him, in the first crystallization, 4. *Sugar of milk, mixed with oil and common salt*, which crystallizes the last. 5. *Sugar of milk, mixed with fat matter, common salt and sal-ammoniac*. It is adhesive and moist, and affords ammoniac on the addition of fixed alkali. 6. And lastly, *Sugar of milk, mixed with all the before-mentioned substances, and likewise with extractive and caseous matter*. This last is of the consistence of honey, becomes rancid, and is acrid and disagreeable.

Sugar of milk, when very pure, has a slightly saccharine, faint, and, as it were, earthy taste; it always loses by successive solutions. It is soluble in three or four parts of boiling water; and, according to Scheele, Rouelle and Vulgamoz, it affords the same products as sugar by distillation. Rouelle obtained from a pound of this salt, by burning it, 24 or 30 grains of ashes; three-fourths of which were muriat of potash, and one-fourth carbonat of potash. On a red-hot coal, sugar of milk melts, boils up, emits an odour of caramel, and burns like sugar. These properties appear to indicate, that this salt is capable of affording the oxalic, like sugar by the nitric acid; and Scheele has shown, by his experiments, that it does: but

he observed, that a large quantity of spirit of nitre is required for this purpose; that four ounces of sugar of milk affords five grains of oxalic acid; and he has also discovered, that if the residues of sugar of milk be treated by the nitric acid, and filtrated, in order to crystallize the oxalic acid by evaporation, a white powder remains on the filter, which he found to be a peculiar acid, we give it the name of *saccholaetic*. He observed, that it possesses the following properties*.

It has the form of a white granulated powder; two drachms of this salt, very pure, being heated in a glass retort, melted, swelled up, and became black; a brown salt, of a mixed smell of benzoin and amber, sublimed, weighing 35 grains; this salt was acid, soluble in alcohol, more difficultly in water, and burned on charcoal. The receiver contained a liquor of a brown colour, and not of an oily nature; eleven grains of charcoal remained in the retort. Carbonic acid and hydrogen gas were disengaged during this distillation. The saccholaetic acid is very sparingly soluble in water, one ounce of boiling water dissolving only six grains; one-fourth of which was precipitated by cooling. According to Morveau, this acid effervesces with the hot solution of carbonate of potash. The saccholaetat of potash was obtained, by cooling, which was soluble in eight times its weight of hot water, and crystallized again by cooling. The salt it formed with the soda was crystallizable, but required no more than five parts of water for its solution. This acid combines likewise with ammoniac; the neutral salt, thus produced, loses its alkali by heat. With barytes, alumina, magnesia, and lime, it forms salts nearly insoluble. It acts but very feebly on the metals, and forms with their oxides salts of difficult solubility. It precipitates the nitrates of mercury, lead, and silver, as well as the muriate of lead.

Scheele, when he first made this discovery, supposed that the white powder, deposited by the oxalic acid obtained from sugar of milk by means of the nitric acid, was merely a portion of the calcareous oxalate formed the lime, which might be contained in that animal salt. But he was soon undeceived, by pouring a small quantity of pure oxalic acid into a solution of

* Scheele's Essays, 277. Journ. de Phys. XXII. 67.

sugar of milk, as the mixture afforded no precipitate. Nevertheless, Hermstadt, who has published two memoirs in Crell's Chemical Journal, the second of which treats particularly of this acid earth, thinks, notwithstanding the experiments of Scheele, that it is a compound of oxalic acid, lime, and a fat substance. But Morveau, after examining the experiments of this chemist with his usual accuracy, and comparing them with those of Scheele, has shown, in the new *Dictionnaire Encyclopedique*, that Hermstadt has not accomplished his undertaking, and that, even from his own results, the discovery of Scheele is rather confirmed than destroyed. Morveau has likewise made several ingenious experiments which confirm this assertion. To these accounts we may add, that the oxalic and saccolactic acids do not exist ready formed in sugar of milk, and that this salt contains only the bases, which take the oxygen or acidifying principle from the nitric acid. We may likewise observe, that subsequent experiments will probably show, that the saccolactic acid is nothing more than a modification of some other vegetable acid; for every circumstance tends to prove, that the principles of whey are derived from the vegetables on which the animals subsist^c.

Haller has given the following proportions of the sugar contained in the milk of different animals.

Four ounces of sheep's milk afforded of

Sugar of milk,	-	-	-	35 or 37 grains.
Goat's milk afforded	-	-	-	47 — 49
Cow's milk,	-	-	-	53 — 54
Human milk,	-	-	-	58 — 67
Mare's milk,	-	-	-	69 — 70
Ass's milk,	-	-	-	80 — 82

Rouelle has observed, that the whey of cow's milk, from which the sugar of milk has been extracted, takes the form of jelly by cooling; and he consequently admits it to contain gelatinous matter.

Cheese, or the caseous matter, takes the solid form, and is separated from the other constituent parts of milk, by the action of fire, by the acid fermentation, and by the mixture of acids. This matter, when well washed, is white, solid, like coagulated albumen, the action of a gentle heat hardens it^f.

Distillation on a water-bath extracts an insipid phlegm, which putrifies.

Dried cheese, distilled in a retort, affords an ammoniacal phlegm, a ponderous oil, and much ammoniacal carbonat. Its coal is dense, very difficultly incinerated, and does not afford fixed alkali. When this coal is treated with nitric acid, it is found to contain lime, and the phosphoric acid^s.

Cheese putrifies in a hot temperature; it swells, emits a nauseous smell, becomes imperfectly fluid, and is covered with a scum, or froth, arising from the disengagement of a very strong-smelling and mephitic gas, which escapes with difficulty from this viscid matter.

Cheese is insoluble in cold water; hot water hardens it. Scheele has observed, that when it has been precipitated by a foreign acid, boiling water dissolves a part.

Alkalis dissolve it, more particularly ammoniac, which, when poured in the quantity of a few drops into milk coagulated by an acid, causes the *coagulum* quickly to disappear^h.

The concentrated acids likewise dissolve cheese; nitric acid disengages azotic gas; but the vegetable acids do not sensibly dissolve it. Its solution in the mineral acids is precipitated by the alkalis, which redissolve it if added in too great a quantityⁱ.

The neutral salts, more particularly muriat of soda, retard its putrefaction. Alcohol coagulates it.

From all these facts it appears, that cheese is a substance greatly resembling the albumen of the blood.

Butter is partly separated from milk by rest; it is collected at the surface, but as it is mixed with much serum, and caseous matter, it is more completely separated by strong agitation, in which the art of making butter consists. A phenomenon takes place in the separation of the cream, and in the formation of butter, which has not been properly understood, but which is worthy of the attention of the philosopher. The contact of air, and the absorption of oxygen, are necessary for the production of butter, and for rendering it concrete. It is not completely formed in the milk; in proportion as it collects on the surface, atmospherical oxygen is absorbed, and gives it a tendency to separate from the other parts of the

milk, by the solidity which it acquires, and by the nature of the concrescible oil which it contains. This is the reason why it can be disengaged by agitation only after a certain time, and also why before the period in which it has absorbed the requisite degree of oxygen, it does not form a mass, or assume a solid form by the strongest agitation^k. The serum, from which butter is separated by agitation, retains a portion of this oily substance, and is yellow, sour, and fat; it is called *butter-milk*^l. Cream is a mixture of cheese and butter, which is skimmed off the surface of milk that has stood for some time. It is much more difficult of digestion than milk itself. If cream be strongly agitated, it takes the form of froth, and is then called *whipt cream*.

Pure butter is concrete and soft, of a yellow colour, approaching more or less to that of gold, and of a mild agreeable taste. It melts by a gentle heat, and becomes solid by cooling. When distilled on a water-bath, it affords a phlegm nearly insipid. By a stronger heat, it affords a very penetrating and strong acid, a fluid oil, and afterwards a concrete coloured oil, of the same penetrating smell as the acid. By rectifying these products, the oil is rendered as fluid and volatile as essential oils. The remaining coal is not abundant. The acid obtained from butter, by distillation, seems to be of the same nature as that of fat, which we shall hereafter mention by the name of the sebatic acid. It may likewise be obtained in the state of neutral salts, by the addition of lime or the fixed alkalis.

Butter soon becomes sour and rancid in a hot air. Its acid is then developed, and its taste is disagreeable. Water and alcohol in some measure restore its original taste, by dissolving the acid. The fixed alkalis dissolve butter, and form a kind of soap which is little known^m.

Hence we find, that butter is an oily substance, of the nature of the fixed vegetable concrete oils.

Fresh butter is mild, temperate, and relaxing. But it readily becomes sour, and in general agrees with few stomachs. Rancid butter, whose acid is developed, is one of the most unwholesome and indigestible of all foods.

Milk is an agreeable food, of considerable use in a great number of cases; it is even one of the most valuable medi-

cines we possess. It corrects the acrid humours in disorders of the skin, and of the articulations. It cicatrises ulcers of a good kind. It may be charged with the aromatic parts of plants, and is then an excellent remedy in the pulmonary consumption. All stomachs, however, do not digest milk. Such persons as are inclined to acidities in the first passages, are usually incommoded by it; and in general it ought to be administered prudently. Milk, rendered medicinal, by causing the animal which gives it to take different substances, is often used with success in various disorders.

The milk of different animals have certain peculiar virtues; that of the human species is mild, of a saccharine taste, and is greatly serviceable in the marasmus. The milk of the ass is successfully used in the pulmonary consumption and the gout; it usually relaxes. Mare's milk resembles that of the ass. Goat's milk is serous, and lightly astringent. Cow's milk is the thickest, the fattest, and the most nourishing; it is likewise the most difficult of digestion, and often requires to be diluted with water, or with some aromatic infusion, especially if it does not easily pass off, or produces costivenessⁿ.

Milk is likewise used externally, as a softening and emollient remedy. It mitigates pain, ripens gatherings and abscesses, and hastens suppuration. It is applied hot, and enclosed in a bladder on the diseased parts.

NOTES ON CHAPTER III.

MILK.

^a It has been found to contain also magnesian earth and iron, and frequently muriat of soda. *Mem. Soc. Med.* 1787-8. 607.

^b The richest milk is said to afford the greatest quantity of alcohol. Pure whey affords none. The milk of the mare is less adapted for undergoing the vinous fermentation than that of the cow. The Tartars are said to add to mare's milk farinaceous matter, in order to make it ferment. Milk must have passed to an acid state before alcohol can be obtained from it by distillation. *Ib.* 422. 611.

^c Acidulous salts and sulphats coagulate milk, when heated to near the boiling point. The nitrats and phosphats have no such effect; nor have the muriats, except the muriat of ammoniac; and at the instant of its dissolution in the milk, ammoniacal vapours are disengaged. *Ib.* 460.

Various metallic salts coagulate milk, particularly the nitro-muriats of gold and tin; the nitrats of silver, mercury, lead, and bismuth; the sulphats of zink, iron, and copper; the acetits of lead, iron, and copper; the muriat of iron. It is remarkable, that the aqueous solutions of the corrosive muriat of mercury, and of the white oxyd of arsenic, have no effect in coagulating milk. *Ib.* 535.

The effect of acids in coagulating milk depends, in some measure, on its temperature. Boiling milk is more speedily and completely coagulated than tepid milk. *Young de Lacte*, 38. When milk has become slightly acid, if it be heated in a water-bath, the caseous part separates, and the whey is neither sour to the taste, nor changes the colour of turnsole. *Mem. Soc. Med.* 1787-8. 477. Acids, when they coagulate milk, combine in part with the caseous matter. *Scheele's Essays*, 266.

Carbonat of potash coagulates milk between 120° and 168° . *Young*, 39. It afterwards dissolves the coagulum, and forms a reddish brown solution.

^a The power of coagulating milk is said to belong to the digesting stomach in all animals. *Hunter, An. Econ.* 172.

Animal rennet coagulates milk most powerfully between 70° and 100° , and not at all above 130° . Its efficacy is not destroyed, when made decidedly alkaline, by mixing with it a small quantity of carbonat of ammoniac; yet it is rendered inefficacious by a greater quantity of that salt, and also by a sufficient admixture of alcohol, or nitrat of potash. The addition of lemon juice increases its coagulating power. *Young*, 23-27.

Young found it impossible to coagulate milk with any of the parts of vegetables, except the purple flowers of the artichoke. These were infused in cold water, with a little salt, and the infusion added to nearly boiling milk. He tried without success the leaves of the artichoke, the flowers of the common thistle, and of the centaury, and the juice of the sorrel. He also anticipated Parmentier and Deyeux in discovering the inefficacy of gelatin. *Young*, 21.

Parmentier and Deyeux, on the contrary, succeeded in coagulating milk with the flowers of the thistle, as well as with those of the artichoke, and likewise with nut-gall, and with acid plants in general. They tried sumach, cinchona, and the bark of the Indian *maronnier*, without effect. *Mem. Soc. Med.* 1787-8. 460. 463.

^c In treating the tartareous with the nitric acid, Westrumb procured a small quantity of a white powder, which had all the properties of the saccholactic acid. *Journ. Phys.* XLII. 432.

The following appears to be the most convenient process for obtaining saccholactic acid. It is given by Boysson, *Mem. Soc. Med.* 1787-8. 619. Once ounce of sugar of milk was dissolved in water, and the solution evaporated to two ounces, which were digested for several days in a gentle heat, with nine drachms of nitric acid. When evaporated to the consistence of honey, the mixture was diluted and filtered, the saccholactic acid, which had been formed, remaining in a white powder on the filtering paper. A fresh quantity of nitric acid was added to the filtered liquor, and the former process repeated, till the whole of the sugar of milk was converted into saccholactic and oxalic acids. By this method, 1 ounce of saccholactic acid, and 9 drachms 48 grains of oxalic acid were procured from 4 ounces of sugar of milk, and 17 ounces of nitric acid.

^f Pure caseous matter melts in the heat of a water-bath, and becomes ductile and semi-transparent like horn; but, when it cools, it hardens again, and becomes brittle. It may be preserved for a long time in this state without putrefaction. *Mem. Soc. Med.* 1787-8. 468.

^g Parmentier and Deyeux sought in vain for the phosphoric acid, which Scheele had announced as being combined with an excess of lime in caseous matter. *Ann.*

Chem. VI. 190. Scheele gives the following account of his discovery.—“After several times abstracting nitrous acid from curds, I at last obtained a white residuum, which was nitrated lime and animal earth. The same earth I obtained from the residuum remaining after the distillation of curds, and its further calcination in a crucible by means of nitre; for, without nitre, this residuum proves very difficult to be reduced to ashes. Thirty parts of dried curds contained about three parts of animal earth.” *Essays*, 268.

^a Fixed alkalis dissolve caseous matter readily, when assisted by heat. During the dissolution, ammoniacal gas is disengaged. This ammoniac is formed in consequence of the action of the alkali upon the caseous matter, for recent cheese contains no ammoniac. Fourcroy asserts, that when dried cheese is used, no ammoniac is disengaged. The solution of cheese in fixed alkali has a reddish brown colour; and when much heat has been used, deposits carbonaceous matter. Acids precipitate from this solution a black fusible substance, of an oily nature, and disengage from it at the same time a particular kind of hepatic gas. This gas has the smell of sulphurated hydrogen gas, and blackens silver, but appears to contain no sulphur. It is probably the same with the animal hepatic gas, discovered by Dr Crawford. *Ph. Tr.* 1790. *Mem. Ac. Sc.* 1789. 314 *Ann. Chem.* VI. 190.

Scheele had long ago observed, that “if curds dissolved in quicklime, or caustic, alkali, be precipitated by vinegar, a disagreeable hepatic smell is produced.”—*Essays*, 267.

Caseous matter dissolves in ammoniac, without the assistance of heat, far more readily than albumen.

^j According to Scheele, “the vegetable acids, and the acid of milk, dissolve little or nothing of the curds.” 266. According to Parmentier and Deyeux, caseous matter dissolves most readily in diluted acids, and particularly in the acetous. *Ann. Chem.* VI. 189. Fourcroy mentions the lactic and diluted sulphuric acids as powerful solvents of caseous matter. *Mem. Ac. Sc.* 1789. 314.

^k Though many circumstances render it probable, that butter absorbs atmospheric oxygen during its separation from the other parts of milk, yet the fact is not decisively established, and some of Dr. Young’s experiments are in opposition to it. Cream, he asserts, separates from milk; and butter is formed by agitation from cream, as speedily in exhausted vessels as in vessels full of air. *De Lacte*, 10, 15. *Ann. Chem.* VII. 168. *Mem. Ac. Sc.* 1789. 310.

Cream has its temperature raised 4° in churning. *Young*, 18.

^l There is no acid evolved in the process of churning. Recent milk affords butter milk without acidity. *Ann. Chem.* VI. 186.

^m It has not been shown, that the rancidity of butter depends on the evolution of an acid. Rancid butter communicates no acid properties to water in which it is melted. *Ann. Chem.* VI. 186. *Mem. Soc. Med.* 1787-8. 444. Butter owes its disposition to rancidity, to the caseous and gelatinous matter which it contains; and, therefore, washing it in water lessens its tendency to become rancid.

ⁿ The milk of ruminating animals contains a greater quantity of caseous matter and butter, and passes more speedily to an acid state, than the milk of non-ruminating animals: The milk of the latter contains a greater quantity of whey and sugar of milk.

Milk passes very slowly to putrefaction.

CHAPTER IV.

CONCERNING FAT.

FAT is a concrete oily matter, contained in the cellular membrane of animals; it is white, or yellowish, with little or no smell or taste, and differs in all animals in its solidity, colour, taste, &c. and likewise in the same animal at different ages. In infancy it is white, insipid, and not very solid; in the adult it is firm, and yellowish; and in animals of an advanced age, its colour is deeper, its consistence various, and its taste in general stronger. The fat of man, and of quadrupeds, is consistent, white, or yellow. That of birds is finer, sweeter, more unctuous, and in general less solid. In cetaceous animals and fishes, it is almost fluid, and frequently placed in peculiar reservoirs, as in the cavity of the cranium. It is likewise found in serpents, insects, and worms: but in these animals it is only met with among the viscera of the lower belly, on which it is placed in separate portions, being scarcely ever observed but in minute quantities, on the muscles, or beneath the skin.

It has been observed, that the fat of frugivorous and herbivorous animals is firm and solid, while that of carnivorous animals is more or less fluid. It must, however, be remarked, that the fat is always less solid and concrete, in the warm and living animal, than in the same animal when dead and cold, in the hands of the dissector.

Fats vary, according to the parts of the animal from which they were taken: it is solid near the reins, and beneath the skin; it is less firm between the muscular fibres, or near moveable viscera, such as the heart, the stomach, and the intestines. It is more abundant in winter than in summer; it appears destined to maintain the heat in those regions wherein it is placed, as many facts, collected by physiologists, demonstrate. It even appears to contribute to the nourishment of animals, as is observable in bears, the mountain rat, the dormouse, &c. and in general all animals, forced to long abstinence, in which the fat melts, and gradually disappears.

To prepare fat for pharmaceutical purposes, or for investigating its chemical properties, it must be cut in pieces, and the membranes and vessels separated; it is afterwards to be washed with much water, and melted in a new earthen vessel, with the addition of a small quantity of water; when this fluid is dissipated, and the ebullition ceases, it must be poured into a glazed earthen vessel, where it fixes, and becomes solid.

Fat has not yet been examined sufficiently to ascertain all its chemical properties. The action of fire, air, and certain menstruums, on this substance, only are known. It is nevertheless highly necessary to be perfectly acquainted with this animal substance, in order to judge of its uses; concerning which nothing is yet certainly known, and more especially the alterations it is subject to in living bodies,

The fat of any animal, exposed to a gentle heat, liquifies, and congeals by cooling. If it be strongly heated, with contact of air, it emits a smoke of a penetrating smell, which excites tears and coughing, and takes fire when sufficiently heated to be volatilized: the charcoal it affords is not abundant. If fat be distilled on a water-bath, an insipid water, of a slight animal smell, is obtained, which is neither acid nor alkaline, but which soon acquires a putrid smell, and deposits filaments of a mucilaginous nature. This phenomenon, which takes place with the water obtained by distillation on the water-bath, from any animal substance, proves, that this fluid carries up with it a mucilaginous principle, which is the cause of its alteration. Fat, distilled in a retort, affords phlegm, at first aqueous, and afterwards strongly acid; an oil, partly liquid, and partly concrete; and a very small quantity of charcoal, exceedingly difficult to incinerate, in which Crell found a small quantity of calcareous phosphat. These products have an acid and penetrating smell, as strong as that of the sulphureous acid. The acid is of a peculiar nature, and has been carefully examined by Crell; but as it is very difficult to obtain by distillation, this celebrated chemist has used a much more certain and expeditious process, which we shall presently describe. The concrete oil may be rectified, by repeated distillation, so as to become very fluid, volatile, and penetrating; in a word, to present all the characters of a true essential, or

volatile oil. Twenty-eight ounces of human fat afforded Crell twenty ounces five drachms forty grains of fluid oil, three ounces three drachms and thirty grains of sebatic acid, three ounces one drachm forty grains of a brilliant charcoal, considerably resembling plumbago, or carbure of iron, as Morveau remarks. Five drachms ten grains of matter were lost in this analysis, which may be attributed to the water in vapour, and the elastic fluids, because Crell did not use the pneumatological apparatus.

Fat exposed to a hot air, alters very quickly; the mild, and scarcely sensible smell, is changed to strong rancidity. This alteration appears to consist of a true fermentation, by which the acid is developed and disengaged. Though this acid appears to be of the nature of the sebatic acid, yet I cannot think that the oily part of the fat is the sole cause of the change, but that the peculiar animal mucilage, which subsequent analysis will discover, has also a share in it. Rancid fat may be corrected by two methods: water alone is capable of carrying off the acid it contains, as Poernér has observed; alcohol has the same property, according to Machy. This proves, that a part of the rancid fat is put into a saponaceous state by its acid, and by that means rendered soluble in water, and in alcohol: either of these fluids may therefore be used with success to deprive fat of its rancidity.

When fat is washed with a great quantity of distilled water, the fluid dissolves a gelatinous matter, which may be exhibited by evaporation; but the fat always retains a certain portion of this matter, with which it is intimately combined, and on which its property of fermenting depends. The action of water on this animal substance has not yet been further inquired into.

Crell, and the chemists of Dijon, have explained the action of alkaline substances on fat. It has been long since known, that the pure alkalis form a kind of soap with fats. Crell, by treating this soap with a solution of alum, or acid sulphate of alumine, separated the oil, and obtained the sebat of potash, by evaporating the fluid. He distilled this salt with concentrated sulphuric acid, which disengaged the sebatic. To deprive this of the portion of sulphuric acid it may be conta-

minated with, Crell directs it to be re-distilled from one-fourth of the sebat of potash, which must be reserved for this use. It may be ascertained that it contains no more sulphuric acid by the addition of the acetit of lead; for if the precipitate be totally soluble in vinegar, it does not contain sulphuric acid. The chemists of the academy of Dijon use a more simple process to obtain the sebatic acid. Suet is melted, and quicklime added; when the mixture is cold, it is boiled in a large quantity of water, which, by filtration and evaporation, affords the sebat of lime, of a brown colour, and acrid taste. This is purified by calcination in a crucible, solution, and filtration; a sufficient quantity of water, impregnated with carbonic acid, being added, to separate the superabundant lime. The fluid being evaporated, affords a white salt, from which, by distillation with the sulphuric acid, the sebatic acid is disengaged.

This acid is formed by heat in the butter of cocoa, spermaceti, and probably in all fixed vegetable oils. The following are its characters: it is liquid, white, and of a very strong smell; it emits white fumes, is decomposed by fire, becomes yellow, and affords carbonic acid. It strongly reddens blue colours; unites, in all proportions, with water; forms a crystallizable salt with lime; and with potash and soda, salts which crystallize in needles, and are fixed in the fire. It dissolves gold, when united with the nitric acid; attacks mercury and silver; precipitates the nitrat and acetit of lead; it decomposes tartaric of potash by precipitating tartareous acidule, or cream of tartar, and likewise decomposes the alkaline acetits. When strongly heated on sulphuric salts, it separates the acid in the sulphureous state. It precipitates the nitrats of mercury and of silver. Many of these properties induced Crell to think, that the sebatic acid might be nothing more than a modification of the muriatic acid; but Morveau observes, that as it decomposes corrosive muriat of mercury, that character alone is sufficient to distinguish them.

Concentrated mineral acids produce a change in fat, which is similar to that produced by combustion. The sulphuric acid gives to it a brown colour, the nitric acid a yellow citron colour.

Sulphur unites very readily with fat, and forms a combination, which has not yet been accurately examined.

Fat is capable of dissolving certain metals ; it unites with mercury in the well known preparation called mercurial ointment. For this purpose, the metal is triturated with hogs lard for a long time ; the mercury becomes divided, attenuated, and so intimately united with fat, that it communicates to it a slate-colour, and loses its metallic form. This union, however, appears to be nothing more than an extreme division, or at most there is only a small portion of the mercury dissolved in the state of a black oxyd by the acid of the fat, since globules of mercury may always be distinguished by a lens in the best prepared ointment.

Lead, copper, and iron, of all the metals, are the most easily altered by fat. The oxyds of these metals combine very readily with this substance ; and for that reason it is dangerous to leave food of a fat nature in vessels of copper, or even in those of earth, which are covered with glass of lead. In the combinations of fat with the oxyds of metals, it is observed, that the latter assume readily the metallic state when heated : this phenomenon arises from the hydrogen gas, which is disengaged from the fat, and unites with the oxygen of the oxyds.

Most vegetable matters are capable of uniting with fat ; extracts and mucilages give it a degree of solubility in water, or at least favour its suspension in that fluid.

It combines with oils in all proportions, and communicates to them a part of its consistence.

These are the chemical properties of fat which are at present known : they teach us, that this substance greatly resembles butter ; that is to say, it is a kind of concrete fixed oil, which owes its solidity to the oxygen which chemists have hitherto attributed to the acid.

With regard to its uses in the animal economy, besides that of maintaining the heat of those parts which it surrounds, and the agreeable plumpness and pliancy it produces, together with the whiteness it communicates to the skin : it likewise appears, according to Macquer, to be of use in absorbing the superabundant acids which may exist in the bodies of living creatures ; it is, as it were, the reservoir of those salts. It is likewise known, that too great a quantity of acid, introduced into the body of an animal, dissolves and melts the fat, doubtless by

rendering it saponaceous, and consequently more soluble. The excessive abundance, and more especially the alterations of the fat, produce dangerous disorders in the animal economy, whose symptoms and effects have not yet been well examined. Lorry has particularly attended to the nature of fat, and has discovered a striking analogy between this substance and bile. This analogy appears indeed to be founded on the fat nature of bile, on the colour which the fat assumes in bilious diseases, on the melting and disappearance of the fat in long continued affections of the liver, on the cruel method of increasing and of softening this viscus in some birds, in melting their fat by long inaction, combined with a dry and long continued heat, &c.

Fat is used in foods, and is nourishing for such persons as have strong digestive powers. It is used externally in medicine, as a softening remedy; and as such it enters into the composition of ointments and plasters.

The marrow, contained in long bones, exhibits the same properties as fat; but the comparative analysis has not been yet made with sufficient accuracy to describe its characteristic properties.

NOTE ON CHAPTER IV.

^a THE nitric acid is decomposed during its action on axunge; the oxygen combines with the axunge, while the azotic gas escapes in a pure state. This action is promoted by heat. If 2 parts of acid be heated with 16 parts of axunge, an ointment of a firm consistence is formed, which has been termed by its discoverer, *Pommade Oxygénée. Essai sur les Propriétés Médicinales de l'Oxygène, par Alton, p. 45.*

CHAPTER V.

CONCERNING THE BILE AND BILIARY CALCULI.

THE bile, or gall, is a fluid of a green colour, more or less yellow, of a strong bitter taste, and of a faint and nauseous smell, which is separated from the blood by a glandulous viscous, universally known by the name of the liver. It is collected in most animals, except insects and worms, in a receptacle near the liver, called the Gall-Bladder. The human bile has not yet been much examined, on account of the difficulty of procuring a sufficient quantity : the gall of the ox has been more particularly examined by chemists.

This liquor is of a glutinous, or almost gelatinous consistence ; it pours out like syrup ; and by agitation, it lathers like soap-water.

When distilled in the water-bath, it affords a phlegm, which is neither acid nor alkaline, but after a certain time putrefies. This phlegm has often exhibited to me a singular character ; it emits an odoriferous smell, of considerable strength, and greatly resembling that of musk or amber. This experiment has often been made in my laboratory. It takes place, more especially when bile, slightly altered by having been kept some days, is submitted to distillation. When all the water which bile affords in the water-bath has been distilled off, the residue has the form of an extract, more or less dry, and of a deep and brownish green. This extract of bile attracts the humidity of the air, is very tenacious and pitchy, and is totally soluble in water ; by distilling it in a retort, it affords a yellowish and alkaline phlegm, an empyreumatic animal oil, much ammoniacal carbonat, and an elastic fluid, consisting of a mixture of carbonic acid and hydrogen gas ; after this operation, a coal remains of considerable bulk, and less difficult to incinerate than those we have hitherto spoken of. According to Cadet, who communicated a very valuable memoir, on the analysis of bile, to the Academy, in the year 1767, this coal contains carbonat of soda, an

animal earth, and a small portion of iron^a. It must be observed, that this distillation must be made slowly, because the matter expands considerably; as to the salt which Cadet mentions, as existing in the charcoal of bile, and which he conceives to be of the same nature with sugar of milk, it is obvious that such a substance could not resist the strong heat necessary to reduce bile to the carbonaceous state.

Bile exposed to a temperature between 65 and 85 degrees, quickly changes, its smell becomes more nauseous, its colour is destroyed, whitish mucilaginous flakes are precipitated, its viscosity disappears, and its smell soon becomes fetid and penetrating. When the putrefaction is in an advanced state, its smell becomes sweet, and resembles amber. Vauquelin has discovered, that the bile of the ox, heated in the water-bath, and slightly evaporated, may be afterwards preserved for many months without alteration, as is likewise the case with respect to vinegar, which has been boiled. He has likewise discovered, that the altered bile of the ox, which exhales a fetid smell, and has a brown dirty and turbid colour, becomes of a beautiful green, and loses its smell when heated, some concrete albuminous flakes are then separated from it.

Bile is very soluble in water; and when thus diluted, becomes of a yellow colour, which is lighter, in proportion to the quantity of water added^b.

All the acids decompose it in the same manner as soap, and produce a coagulum. If this mixture be filtrated, and the fluid evaporated, a neutral salt is obtained, which is found to consist of the acid made use of and soda. This valuable experiment, first made by Cadet, proves the existence of soda in the bile. The matter remaining on the filter, in these experiments, is thick, viscid, very bitter, and very inflammable; its colour and consistence vary, according to the nature and concentration of the acid made use of. I have observed, that the sulphuric acid gives it a deep green colour; the nitric acid, somewhat concentrated, a brilliant yellow; and the muriatic acid, a very beautiful light green colour: these colours, however, vary greatly, according to the state of the bile, and of the acids. This precipitate has been considered as a substance

similar to resin, which swells, melts, and takes fire on hot coals, is totally soluble in alcohol, and water precipitates it like the resinous juices. The action of acid on bile, proves, therefore, that it is a true soap, formed by an oil of the nature of resins, combined with soda. They likewise indicate the presence of a certain quantity of the albuminous matter in this animal fluid, which causes it to coagulate by fire, by acids, and by alcohol; it is the same principle likewise which produces its putrefaction.

Neutral salts, mixed with bile, prevent its putrefaction.

Metallic solutions, and bile, mutually decompose each other; the soda of this humour unites to the acid of the solution, and the coloured oil of the bile precipitates in combination with the metallic oxyd.

Bile unites readily with oils, and takes them out of cloths in the same manner as soap^c.

This fluid is soluble in alcohol, which separates the albuminous matter. The tincture of bile is not decomposed by water; which shows, that this substance is a true animal soap, equally soluble in aqueous and spirituous menstrua. Ether likewise dissolves it very readily.

Vinegar decomposes bile in the same manner as the mineral acids; when the filtrated liquor is evaporated, the acetit of soda is obtained, well crystallized.

From these several experiments, it follows, that bile is a compound of much water, a peculiar aroma, albuminous muciilage, a peculiar concretable oil, and carbonat of soda^d. Cadet found it to contain a salt, which he thinks to be of the nature of sugar of milk, and whose existence has been since confirmed by Van Bochaute. But it is probable, that this pretended saline matter, is rather analogous to the lamellated shining and crystalline oily substance, which Poulletier discovered in the human biliary calculi, and of which we are about to treat.

Bile, considered with respect to the animal economy, is a fluid which appears to assist the process of digestion. Its saponaceous quality renders it capable of uniting oily substances with water. Its bitter taste proves, that it stimulates the intestines, and promotes their action on the aliments. Roux, a celebrated physician and chemist of the Faculty of Medicine at

Paris, whose premature death is a heavy loss to the sciences, was of opinion, that the bile is likewise principally calculated to evacuate the colouring part of the blood from the body^e. It appears to be decomposed in the duodenum, by the acids which are almost always disengaged in digestion. It is certain, at least, that it is greatly altered, especially in its colour, when it composes part of the excrements. Judicious physicians may therefore, in many cases, make useful inferences from the inspection of these matters, which indicate the state of the bile, and that of the liver, which separates it.

The extract of the gall of bullocks, and of many other animals, is used as a very good stomachic medicine. It supplies the defect and inactivity of the bile, restores the tone of the stomach, and establishes the functions of that organ, when debilitated; but great care must be taken in its use, because it is acrid and heating; and it must be administered only in very small doses, especially in irritable subjects. Of the biliary calculi some ascribe peculiar virtues, to the gall of fishes; but the notion has not been confirmed by experience, and it is to be ranked in the too numerous class of prejudices which still exist in the *matéria medica*.

Whenever the human bile is detained in the gall-bladder by any cause, and especially by spasmodic contractions, as in melancholic or hysterical disorders, long continued grief, &c. it thickens, and produces brown, light, inflammable concretions, of a very strong bitter taste, which are called *biliary calculi*. These concretions are often very numerous, distending the gall-bladder, and sometimes entirely filling it. They produce violent hepatic cholics, vomiting, jaundice, &c. I distinguish them into three varieties: the first are brown, blackish, irregular, tuberculated, and formed, as it were, by biceps. The second, which are harder, brown, yellowish, or greenish, exhibit concentric layers, and are often covered with a dry, smooth, and grayish crust. Their form is commonly angular and polyhedral. The third variety comprehends the white, oval concretions, more or less irregular in their form, covered with a whitish, and often unequal crust, in layers of a pathose appearance, or in transparent crystalline plates, often radiating from the centre to the circumference.

The biliary calculi, of the second variety, have been examined by Poulletier de la Salle. He has observed, that they are dissoluble in alcohol. After having digested the stones in strong spirit of wine for a certain time, he observed, that the fluid was filled with slender, brilliant, crystalline particles, having all the appearances of a salt; and the experiments made on this saline substance, gave occasion to suspect, that it was an oily salt, similar, in some of its properties, to the acid salt, known by the name of *flowers of benzoin*, but its nature is not at all known^f. From the experiments of this philosopher, it seems, that this salt is only contained in the biliary calculi of man, as he did not find it in those of oxen. This singular fact requires to be confirmed; for Vauquelin and I have found a small quantity of lamellated matter in the calculi of the ox.

The discovery of Poulletier de la Salle has thrown light on some facts, collected by the Royal Society of Medicine, respecting the stones of the gall-bladder. This society received from several physicians, biliary calculi of the third variety we have mentioned, which have not hitherto been described. They consist of a mass of crystalline transparent laminae, similar to mica, or talc, which have absolutely the same form as the salt discovered by Poulletier. It even appears, that the human bile is capable of affording a great quantity of these crystals; for the Society of Medicine is in possession of a gall-bladder entirely filled with this saline transparent concretion. I have two others of the same kind, which were given to me by my colleagues Leprieux and Halli. On examining these crystallized biliary calculi. I have found that they are of an oily nature, similar to spermaceti.

Soap, the mixture of oil of turpentine and ether, &c. have been proposed to dissolve the biliary calculi. It is an important observation, that they are only found in the gall-bladder of oxen, after dry seasons, and a scarcity of fresh fodder; and that they disappear in the spring and summer, when these animals find abundance of green and succulent vegetables. The butchers are well acquainted with this phenomenon; they know that these stones are found in oxen from the month of November to the month of March, and not afterwards. This phenomenon sufficiently shows the power of the saponaceous juices

of plants in dissolving the biliary calculi. Yet it is not to be thought, that medicines, however active and volatile, can be introduced into the gall-bladder in sufficient quantity to dissolve the biliary calculi, with the same energy as in our experiments. In my opinion, the cessation of spasm, and consequently the dilatation of the biliary canal, is the true cause of the good effects of the ethereal mixtures that have been proposed by Durande, which I have elsewhere recommended to be made up without oil of turpentine; besides, being very heating, it produces no useful effect, but that of diminishing the volatility of the ether; and it has been already proved, that the yolks of eggs, and undoubtedly many other substances, will serve the same purpose as well, and without the same inconveniences &c.

NOTES ON CHAPTER V.

BILE.

^a CADET also obtained a small quantity of muriat of soda from the ashes of bile, and Richter succeeded in procuring the same salt from bile, without calcination. The carbonaceous residue of bile emits an alliaceous smell during its incineration, and has therefore been supposed to contain phosphoric acid. Fontana alleges, that the bile of the ox contains phosphat of magnesia. *An. Chim.* IV. 172. The existence of calcarous earth in the residue of bile was discovered by Cadet. Richter sought in vain for the iron which Cadet had detected in the same residue. *Richter circa bilis naturam Erlangæ, 1788, 27.* When the residue of bile, after distillation, is burned, the soda is apt to be volatilized. *An. Chim.* VII. 180.

^b Bile, diluted with water, is said to become sooner putrid than when undiluted. *Fordyce on Digestion, 68.*

^c It was attempted to combine bile with vegetable and with animal oils, by agitation and by trituration, but without success. Bile appeared to be less disposed to unite with oil, than either mucilage or saliva. *Ramsay de Bile, Edinburgh, 1757. Cap. 3.* M^cLurg had the same want of success. *On Bile, 10.*

^d The albuminous part of bile was distinguished from the resinous part by Ramsay. He relates, that a white, viscid, putrescible matter, was separated from bile by alcohol. He adds, that when the extract of bile, or the precipitate of bile by acids, was digested in alcohol, this putrescible part remained undissolved. He also found that it could be separated from bile by acetous and pyrolignous acids, and by sulphat of potash. None of these substances precipitated the resin of bile. *De Bile, 1757.*

The resin of bile, as it is called, resembles, in some particulars, the vegetable

refins, but differs from them essentially in many of its properties. It melts at 122° . It is extremely inflammable, and burns with rapidity, like any bituminous substance. It is soluble in alcohol, and precipitated from it by water. It is acrid and bitter to the taste; but it is dissolved by caustic alkalis, and is even soluble in water. It is precipitated, without change, by diluted acids, from its solution either in water or in alkalis. It is said to afford sebatic acid by distillation. *Ramsay de Bile*, 1757. *Fourcroy, Mem. Soc. Med.* 182-3, and *Ann. Chim.* VII. *Saunders on the Liver*, 1793.

The refin of bile is precipitated by oxygenated muriatic acid in a white concrete form resembling tallow. The refin in this state, though it has lost its colour and smell, retains its bitterness. It has become more fusible, and melts about 104° . It dissolves readily in warm water, and in alcohol, without the assistance of heat. When it is heated with alcohol, a quantity of ether is formed. It is still precipitated by acids from its solution in water; and though soluble both in water and in alcohol, the addition of water to its solution in alcohol occasions a copious precipitation. *Ann. Chim.* VII. 176.

^e Dr. Bostock of Liverpool has succeeded in forming a substance extremely similar to the refin of bile, from the crassamentum of blood digested with the nitric acid. Two ounces of crassamentum were boiled with one ounce of nitric acid, till the whole of the crassamentum was dissolved. During the dissolution, a great quantity of azotic gas was disengaged, and a small quantity of nitrous and carbonic acid gas. When the solution cooled, a lamellated substance, consisting chiefly of adipo-cire was deposited, and the supernatant liquid was of a dark green colour. It was saturated with potash. No precipitation followed, but the crystals of nitrat of potash procured by evaporation were impregnated with a brownish-coloured matter, soluble in alcohol. This matter, when separated from the alcohol, had a pitchy consistence, a deep yellow colour, and a bitter taste. When boiling water was poured on the adipo-cire, a similar matter was procured from it. *De Secretione, Edin.* 1798.

Welter has also procured a crystalline substance, possessing some of the properties of bile, by repeatedly treating silk with nitric acid. This substance he calls *amer* (*bitter*). It has the bitterness of bile, and is soluble both in water and in alcohol; but it is volatile in the fire, crystallizes in regular forms, and its colour, which is yellow, is extremely fixed. It also forms with nitrat of potash, a triple compound which has a golden colour, and detonates like gunpowder. *Ann. Chim.* XXIX. 301.

^f From the subsequent experiments of Fourcroy, it appears, that this crystalline matter is hardly at all soluble in alcohol, at the temperature of 55° ; but at the temperature of 167° , one part of it is dissolved by 19 parts of alcohol. It is infusible at the temperature of 234° . *Ann. Chim.* VII. 190.

^g On the subject of biliary calculi, consult *Encyclopedie Methodique Chimie. Ann. Chim.* III. V. & XVI. *Saunders on the Liver* 1793. *Delius de Cholelithis*, 1782. *Simmering de Concrementis Biliariis*.

CHAPTER VI.

CONCERNING THE SALIVA, THE PANCREATIC JUICE, AND THE
GASTRIC JUICE.

ANATOMISTS and physiologists have observed a great analogy between the saliva and the pancreatic juice. The salivary glands, and the pancreas, have in fact a structure entirely of the same kind, and the use of the fluids, secreted by these organs, appears to be the same. Man, and quadrupeds, are the only animals in which the saliva exists; or at least the salivary glands have not been observed in any other animals.

No accurate chemical experiments have yet been made with these two fluids. This circumstance may be attributed to the difficulty of procuring either, even in very small quantities. It is only known, that the saliva is a very fluid juice, separated by the parotides, and many other glands, which continually flows into the mouth, but most abundantly during mastication. It appears to be of a saponaceous nature, impregnated with air, which renders it frothy; it leaves but a small residue, when evaporated to dryness; but it forms, nevertheless, certain salivary concretions in the passages which convey it into the mouth. It appears to contain an ammoniacal salt, since lime and caustic fixed alkalis disengage from it a penetrating and urinous odour^a. Pringle, from experiment concluded, that the saliva is very septic, and that it favours digestion, by exciting a commencement of putridity in the aliments. Spallanzani, and many other modern physicians, think, on the contrary, that it possesses the property of retarding and impeding putrefaction.

The gastric juice is separated by small glands, or the arterial extremities, which open into the internal tunic of the stomach. The œsophagus likewise affords a small quantity, especially in the inferior region. Glands of considerable magnitude are observed in many birds, which open into very sensible excretory ducts. Vicq. d'Azyr has carefully described those which appear in the stork.

Some modern philosophers have paid great attention to the gastric juice. Spallanzani, Scopoli, Monch, Brugnatelli, Carminati, have, within the last few years, examined the properties of this liquor. They collected it in the stomach of sheep and calves, by opening them, after having suffered them to fast for some time. They obtained it from carnivorous and gallinaceous birds, by causing them to swallow spheres and tubes of metal, pierced with holes, and filled with very fine sponge. Spallanzani examined the gastric juice of his own stomach, by procuring a vomit, or by swallowing wooden tubes, filled with different substances, to judge of the effect of the gastric juice on each of them. The experiments with tubes had been before attempted by Reaumur. Lastly, Gossé of Geneva had the courage to cause himself to vomit a great number of times, by a process which is peculiar to himself, and consists in swallowing the air. From all the modern observations, the gastric juice appears to possess the following properties.

It is the principal agent of digestion, and changes the aliments into a kind of uniform soft paste: it acts on the stomach itself after the death of animals. Its effects show, that it is a solvent, but of that peculiar nature, that it dissolves animal and vegetable substances uniformly, and without exhibiting a stronger affinity for the one than for the other. Far from being of the nature of a ferment, it is one of the most powerful antiseptics we are acquainted with: and from the experiments of the philosophers before cited, its nature appears to be essentially different in the several classes of animals. According to Brugnatelli, the gastric juice of birds of prey, and granivorous birds, is very bitter, and composed of a disengaged acid, resin, animal matter, and common salt; that of ruminating quadrupeds is very aqueous, turbid, and salt, containing ammoniac, an animal extract, and common salt. Morveau, having digested portions of the internal tunic of the stomach of the calf in water, found that it has an acid character. Spallanzani thinks, that this character depends on the aliments, as he never found the acid gastric juice in the stomach of carnivorous animals, but always in those which feed on grain. Gossé made the same observation on himself, after having used crude ve-

getables for a long time. Brugnatelli thinks, that the white matter, in the excrements of carnivorous birds, contains phosphoric acid; but Morveau observes, that his experiments are not conclusive*. Scoppuli found muriat of ammoniac, and suspects that the muriatic acid is produced by the vital power of animals; but no decisive fact has been brought in support of this opinion; every circumstance, on the contrary, tends to show, that this acid comes from the food. Macquart and Vauquelin have found, that the gastric juices of the ox, calf, and sheep are constantly possessed of an acid character; but it appears from their accurate experiments, that it is the disengaged phosphoric acid which gives to them this character†. They have also discovered that these juices alter and soon putrefy. The gastric juice of carnivorous animals possesses the antiseptic qualities in the highest degree.

Hence it may be concluded, 1. That the gastric juice is not well known; 2. That it appears to be different in several classes of animals, and in the same animal, according to the diversity of food; 3. That no proof has been brought to show that it is a peculiar acid, and that we should acknowledge the existence of a gastric juice; 4. That its most remarkable property consists in its great solvent power, which extends even to bony and metallic substances; and it is even said to be capable of attacking siliceous stones; an indifference or equal attraction for the matters it acts on^b.

Its very strong antiseptic quality, which it communicates to all the bodies it is mixed with, and which even puts a stop to putrefaction, in substances which have already begun to be changed by that process, has excited a greater degree of attention than the others. Carminati, Jurine, and Toggia, have applied the gastric juice on wounds. Carminati has even used it internally; and they all agree with respect to its antiseptic virtue‡. But the experiments of Macquart and Vauquelin, which I have formerly quoted, and which were made in my own laboratory, prove, that this antiputrid quality does not belong to the gastric juice of ruminating animals.

* *Encyclopedie Methodique*, I. 41.

† *Journ. Phys.* XXXIII. 380. *Mém. Soc. Méd.* 1786. 355.

‡ *Journ. Phys.* XXVI. 161.

NOTES ON CHAPTER VI.

^a THIS is a very inadequate proof of the presence of ammoniac in saliva. Caustic alkali, extricates ammoniacal vapours from animal substances, which contain only the elements of ammoniac, by enabling these elements to unite together, in consequence of its own affinity for the elements with which they were formerly combined.

Saliva contains an animal matter, coagulable by the corrosive muriat of mercury. It is also rendered turbid by alcohol. *Fordyce de Catarrha, Edin. 1758.*

The saliva of the horse, contains an animal matter coagulable by boiling water and by acids, and precipitated by alcohol. It also holds in solution, carbonat of soda, and muriat of soda. *Mem. Soc. Med. 1780-1. 325.* The human saliva also contains a sensible quantity of muriat of soda.

^b Fourcroy seems to over-rate the solvent powers of the gastric juice; it acts upon food rather as a decomposing principle than as a solvent: but, indeed, its powers are known with as little precision as its chemical composition. They have been rather extolled with blind admiration, than investigated in the spirit of analysis.

It appears from the curious experiments of Mr. Smith, that the subcutaneous parts of living animals, when wounded, or stimulated, pour out a secretion analogous to the gastric liquors in the property of coagulating milk, and in acting as a decomposing principle on animal and vegetable substances. *Ann. Chim. XXIX. 110.*

CHAPTER VII.

CONCERNING THE HUMOURS, OR ANIMAL MATTERS, WHICH HAVE NOT YET BEEN EXAMINED; SUCH AS SWEAT, THE NASAL MUCUS, THE CERUMEN, TEARS, THE GUM OF THE EYES, THE SEMINAL FLUID, AND THE EXCREMENTS.

THERE are many animal fluids and matters, which have not yet been examined. It is therefore not so much with a view to exhibit their properties, as to engage young physicians to make researches, equally new and useful, that we propose to speak cursorily respecting the humour of transpiration, of sweat, of the mucus of the nostrils, the cerumen of the ears, the tears, the gummy matter of the eyes, the seminal fluid, and the excrements.

I. Physicians have discovered a great analogy between the fluid emitted by cutaneous transpiration and urine; they have observed, that these excretions mutually answer the same purpose in many circumstances, and are therefore naturally led to consider the vapourous fluid of transpiration, as of the same nature as urine. Medical practice has shown, that its qualities are subject to variation; that its smell is faint, aromatic, alkaline, or sour; that its consistence is sometimes glutinous, thick, tenacious, and that it leaves a residue on the skin; that it often tinges linen with various shades of yellow. I have twice observed it to communicate a bright blue colour to linen and woollen shifts. Berthollet affirms, that sweat reddens blue paper; and that this phenomenon takes place more particularly in parts affected with the gout. He thinks it contains the phosphoric acid*. It has been hitherto impossible to collect a sufficiently large quantity of this excrementitious humour, to examine its properties with accuracy. Many inquiries, therefore, remain to be made, which can only be undertaken and pursued by physicians in peculiar circumstances and occasions a.

II. The humour, prepared by the membrane of Schneider, which is thrown out of the nostrils by sneezing, deserves to be

* Journ. XXVIII. 292.

carefully attended to by physicians. It is a kind of thick mucilage, white or coloured, more or less fluid, or consistent in certain affections, and more especially in catarrhs. It appears to be a mucus and alkaline substance, which becomes thick, in consequence of absorbing oxygen from the atmosphere^b.

III. The yellow, greenish, or brown matter, which is collected, and becomes thick, in the auditory canal, and is known by the name of *cerumen*, because of its consistence, has not been examined. It is very bitter, and appears to be of a resinous nature; it sometimes becomes so concrete, as to stop the auditory canal, and prevent the free passage of sound: there seems to be some analogy between this and the inflammable matter of the bile^c.

IV. We are better acquainted with the nature of the tears, which are prepared in a peculiar gland, situated towards the external angle of the orbit, and destined by nature to maintain the humidity and suppleness of the external parts of the eye. This fluid is clear, limpid, and manifestly salt; it sometimes issues out of the eye in large quantities. In the natural state, it gradually flows into the nostrils, and appears to dilute the mucus. Most authors who have spoken of this liquor, and in particular Pierre Petit, a physician of Paris, who published a treatise on Tears about the end of the last century, consider them as water nearly pure. We have found them to contain a peculiar mucilage, which becomes thick by absorbing oxygen, muriatic soda, and soda, in a caustic state; after that, the humour of the tears is similar to the mucus of the nose with which it mixes.

V. Neither has the chemical nature of the feminal humour been more inquired into than that of the foregoing matters:—The few observations, which it has been hitherto possible to make on this humour, have shown, that it resembles animal mucilages, becomes fluid by cold and by heat, and that the action of fire reduces it to a dry and friable substance.

The anatomical and microscopical observations on this subject have been carried much further. They have shown, that the feminal humour is an ocean, in which certain small round bodies swim, which possess a rapid motion, and are by some considered as living animals, destined to reproduce the species, and by others as organic molecules, adapted to form a living

being by their union. The microscope, in the hands of a modern observer, has likewise shown crystals formed in the feminal liquor by evaporation and cooling. It must be admitted, however, that these fine experiments have not hitherto been attended with consequences which have advanced the sciences, but that they have merely afforded data for the construction of certain ingenious hypotheses.

Vauquelin has published, in the *Annales de Chimie*, (April 1791) a memoir on the Human Semen. The following are the new facts which it contains :

1. This substance has a faint smell, a sharp and slightly astringent taste, its weight is greater than that of water.

2. To ascertain whether the air be the cause of the liquefaction, which this humour undergoes some minutes after it has been emitted, he exposed equal quantities of it in the air, and in close vessels containing no air. The liquefaction having taken place in the same manner, and in the same time, he concluded, that neither the air, nor the substances dissolved in it, produced this effect.

3. By leaving the feminal liquor to liquify in a small glass ball, terminated by a very narrow tube, its volume was not increased. This was easily observed, by marking the place to which the liquor rose. He seems to doubt whether this effect is to be ascribed to caloric.

4. When the semen is kept for some days exposed to the air, in a small capsule, long transparent crystals are deposited in it, of the shape of a prism with four sides, terminated by pyramids with four faces. According to the experiments of this author, these crystals, which had been announced in the *Journal de Physique*, are very pure phosphat of lime.

5. A very white pellicle, forming on the feminal liquor, some time after it has been exposed to the air, which is set with opaque white points. These points are of the same nature with the succeeding crystals, and differs from them only in not being transparent.

6. If the air in which the feminal matter is exposed be humid, it does not dry completely, but remains soft and ductile. Before arriving at this state, it undergoes many changes, which Vauquelin has carefully described. At first, it assumes a yel-

low colour, becomes acid. Byfi grow on its surface, crystals are deposited in it, and at last it exhales the odour of putrid fish. If, on the contrary, the air be dry and warm, the semen dries, speedily becomes dry and brittle, like horn; it loses, during the desiccation, about nine-tenths of its weight.

7. The feminal liquor exhibits a very marked alkaline character, which is owing to the soda the author has discovered in it.

8. Water, at whatever temperature it may be, from zero to the boiling point, does not dissolve semen that has not been previously liquified, but it combines with the semen at every temperature, when once this fluid has become liquid. This, Vanquelin observes, shows that some changes takes place, either in the texture, or organization, or intimate nature of the semen during its liquefaction.

9. All the acids, excepting the oxygenated muriatic acid, dissolve the feminal liquor very readily. Alkalis cannot disengage it afterwards under a solid form. The oxygenated muriatic acid, instead of dissolving it, reduces it into white flakes, which become yellow, if a large quantity of this acid be added. Urine, by means of its disengaged acid, likewise dissolves the seminal matter.

10. The feminal liquor when fresh, does not decompose barytic salts, whilst it decomposes them after being long exposed to the air. This effect is owing to the carbonic acid of the air, which is absorbed by the soda contained in the semen, and which communicates to it the property of decomposing barytic salts. All the calcareous, magnesian, and aluminous salts, are decomposed by the semen, because the soda has a stronger attraction for acids than these earthy matters have. The metallic salts are still more readily decomposed by this substance.

11. By distillation, the dry semen affords, 1. Some drops of water; 2. An elastic fluid, consisting of carbonic acid, and of carbonated hydrogen gas; 3. An empyreumatic oil; 4. Carbonat of ammoniac; 5. A very light charcoal remained in the retort.

12. To discover the proportions of the substances which the preceding experiments had discovered in the semen, Vanquelin took forty grains of it in a dry state, which was equal to

400 grains of it when fresh, since it loses nine-tenths of its weight by drying, and heated them in a crucible of very pure white clay. This substance swelled, emitted yellowish ammoniacal fumes, and was converted into charcoal, when a very strong heat disengaged no longer any from it; the crucible was taken from the fire, the charcoal which it contained was washed, and the lixivium afforded, by evaporation, eight grains of a salt, known by its properties to be carbonat of soda. The lixiviated charcoal was again exposed to the fire, it burned readily, and twelve grains of white ashes remained, which had no taste, which did not dissolve in water, and which melted with the blowpipe into an opaque globule, that emitted a phosphoric light, while it continued in fusion. This substance dissolved in acids, its solution was precipitated in white flakes by all the alkalis, and by lime water. A solution of it in muriatic acid evaporated to dryness, and afterwards treated with highly rectified alcohol, was divided into two portions; one of these dissolved in alcohol, afforded, with the oxalic and sulphuric acids, precipitates of the oxalat and sulphat of lime, and with potash of pure lime. The other portion which remained of a thick consistence, was melted by the blowpipe into a transparent glass, which was soluble in water, and the solution of which precipitated lime water, and reddened blue vegetable colours. This analysis proves, that this last substance is composed of lime, and of phosphoric acid, like the basis of bones.

It follows, from the preceding experiments, that the human semen is composed,

1. Of animal mucilage,	6 parts.
2. Of soda,	1
3. Of phosphat of lime,	3
4. Of water,	90
	100

VI. The food, by which animals are supported, contain a large quantity of matter, which is not capable of nourishing them, and is rejected out of the intestines in a solid form. The excrements are coloured by a portion of bile, which they carry

with them. The fetid odour they exhale, arises from the commencement of putrefaction in their passage through the intestines. Homberg is the only chemist who has examined these matters. He observed, that the phlegm afforded by excrements distilled on the water bath, was of a nauseous smell; by washing and evaporation, he obtained a salt, which melted like nitre, and took fire in close vessels. The distillation of this matter, in a retort, afforded the same products as other animal substances. Putrefied excrements afforded an oil without colour or smell, which did not convert mercury into silver, as he had been led to expect*.

It must be observed, that the fecal matter examined by Homberg, was that of men, fed with coarse bread, and champagne wine; a circumstance which was said to be essential, in order to succeed in the alchemical experiments he was directed to make. There can be no doubt, but that the properties of the excrements must depend on the nature of the food, of which they are merely the residue. An accurate, and careful analysis of the excrements of different classes of animals, is one of the most certain means of discovering the phenomena of digestion. Several chemists are at present engaged in it.

* Mem. Acad. Sc. 1711.

NOTES ON CHAPTER VII.

^a It appears from the experiments of Mr. Cruickshank and Mr. Abernethy, that the matter of insensible perspiration on the state of health, consists of little else than pure water, containing a very small quantity of animal matter, and muriat of soda.

^b See an excellent paper on the mucus and tears, by Fourcroy and Vanquelin. *Ann. Chim.* X. 113.

Fordyce had long before pointed out the difference between recent mucus, and mucus exposed for some time to the air. He had also remarked, that the animal part of mucus is coagulated by the common muriat of mercury. *De Catarrho, Edin.* 1758.

^c Cerumen is a compound substance, consisting of a number of whitish particles, connected together by a tenacious matter, which is soluble in warm water. Cerumen differs from bile in being insoluble in alcohol, and not being decomposed by diluted acids. *Medical Communications*, IV.

CHAPTER VIII.

CONCERNING URINE.

URINE is a transparent excrementitious fluid, of a citron yellow colour, a peculiar smell, and a saline taste, separated from the blood by two glandular organs, called kidneys, and from thence conveyed into a reservoir, which is universally known by the name of the bladder, and in which it remains for a certain time. This fluid is a kind of lixivium, containing the acrid matters of the animal humours, which, if retained too long in the body, might be productive of mischief and inconvenience. It is a solution of a great number of salts, and two peculiar extractive substances; and its quantity and quality varies according to circumstances. The urine of man, which we propose to examine in particular, differs from that of quadrupeds; and the differences are still more considerable between the other classes of animals. The state of the stomach, and that of the fluids in particular, produce a great number of alterations, which cannot be ascertained but by a long continued series of experiments, few of which have yet been made. We shall therefore only speak, in this place, of the urine of the human species in a healthy state.

This fluid is distinguished by physicians into two kinds; the one, called crude urine, when emitted a short time after meals, is clear, and almost destitute of taste and smell; it contains a much smaller proportion of the principles than the other, which is called urine of the blood, or urine of concoction.

This last is not emitted till the process of digestion is finished, and it is separated from the blood by the kidneys; while the former appears to be filtrated, in part, from the stomach and intestines immediately to the bladder, by means of the cellular membrane, or by the absorbent vessels.

The state of health, and especially the disposition of the nerves, have singular effects on the urine. After hysteric or hypochondriac attacks, it flows in large quantities, and is without smell, taste, or colour. The disorders of the bones, and of the articulations, have likewise a great influence on this ani-

mal lixivium. It often deposites a great quantity of matter, apparently earthy, but which seems to be the lithic acid, and a calcareous phosphat, as we shall hereafter observe. The urine of those who have the gout is of this kind. Physicians, particularly Herissant and Morand, have observed, that when the bones are affected, or become soft, the urine deposites a large quantity of this matter. It is likewise observed, that in the healthy state, the urine contains a quantity of this matter, which is the basis of bones, and was probably more than was required for the nutrition and reparation of those organs.

Many foods are capable of communicating certain peculiar properties to urine. Turpentine produces a smell of violets, and asparagus a very fetid smell, in this fluid. Such persons as have weak stomachs, void urine, which retains the smell of such foods as they have taken. Bread, garlick, onions, soup, and all vegetables, communicate their own proper smell to the urine. From these facts, it follows that the urine exhibits phenomena, from which the physician may derive the greatest practical advantages. But it must not be concluded, that a simple inspection of the urine is sufficient to determine the nature of a disorder, the sex of the patient, and the remedies which are proper to be applied, as certain empirics pretend.

The human urine, considered with respect to its chemical properties, is a solution of a considerable number of different substances. Some of these are salts, similar to those of minerals, and, as Macquer, thinks, are derived from the foods, without having suffered any alteration. Others are found to be analogous to the extractive principle of vegetables; and lastly, there are others which appear to be peculiar to animals, and even to urine, or which have not at least been found in considerable quantities in the products of the other kingdoms, nor even in the other animal substances, except urine. After having shown the method of extracting these several matters from urine, we shall proceed to the history of such as are peculiar to this fluid, and have not yet been described.

Urine was formerly considered as an alkaline liquor, or lixivium; but Berthollet has remarked, that it always contains an excess of phosphoric acid, and reddens the tincture of turn-

sole*. This physician has observed, that the urine of gouty persons contains less acid than that of persons in perfect health; that, during the fit of the gout, this fluid is much less acid than usual. He conjectures, that in gouty patients, the phosphoric acid is not evacuated by urine, as in healthy persons; that it wanders, as it were, and is carried into the articulations, where it excites irritation and pain. This excess of acid in the urine appears to hold the calcareous phosphat in solution.

Scheele seems to think, that this disengaged acid of urine is not merely phosphoric acid, but consists of partly the same acid as he has discovered in the human calculus, which we call the *lithic acid*. The latter acid, which is capable of concretion and crystallization, forms, according to this celebrated chemist, the red crystals which are deposited from urine, and also the brick-coloured precipitate, observed in the urine of such as have fevers. The tephaceous concretions, in the articulations of gouty persons, are likewise of the same nature as the calculus; that is to say, for the most part formed of the lithic acid.

Fresh urine, distilled in the water bath, affords a large quantity of phlegm, which is neither acid nor alkaline, but quickly putrefies. As this phlegm contains nothing particular, the urine is commonly evaporated on a naked fire. In proportion as the water, which forms more than seven-eighths of this animal humour, is dissipated, the urine becomes of a brown colour; a pulverulent matter is separated, of an earthy appearance, which has been taken for calcareous sulphat, but is a mixture of sulphat of lime, calcareous phosphat, and lithic acid. This salt, therefore, contains substances of the same nature as the solid basis of bones, and the stone of the bladder. When the urine has obtained the consistence of a clear syrup, it is filtrated, and set in a cool place; at the end of a certain time, saline crystals are deposited, which consist of muriat of soda, and two peculiar saline substances. These salts are known by the names

* Coldevillars had mentioned in his Course of Surgery that urine constantly reddens the tincture of turnsole.

of *fusible salts*, or *native salts of urine*, and *alkaline phosphats*; we shall examine their properties in the following chapter. Several successive products of these crystals are obtained, by repeated evaporations, at the same time that a certain quantity of muriat of soda and muriat of potash crystallizes. When the urine affords no more saline matter, it is in the state of a very thick brown fluid, which is a kind of mother water, and holds in solution two peculiar extractive substances. By evaporating it to the consistence of a soft extract, and treating the residue with alcohol, Rouelle, the younger, has discovered, that a portion is dissolved, and the other part remains untouched. He calls the first *saponaceous matter*, and the second *extractive matter*.

The saponaceous substance is saline, and capable of crystallization. It is not dried without difficulty; and in this state it attracts the moisture of the air. By destructive distillation, it affords half its weight of ammoniacal carbonat, a small quantity of oil, and ammoniacal muriat. Its residue converts the syrup of violets to a green.

The extractive substance, soluble in water, and not in alcohol, is easily dried in the water-bath, like the extracts of plants; it is black, less deliquescent than the former, and affords, by distillation, all the products of animal matters. Such, according to Rouelle, are the characteristic properties which distinguish these two component parts of the extract of urine. We may likewise add, that this celebrated chemist obtained from one ounce to an ounce and a half of extract from a pint of urine, voided after concoction; whereas the same quantity of crude urine afforded no more than one, two, or three drachms.

If the extract of urine, instead of being separated by alcohol, be distilled entire, it affords much ammoniacal carbonat, a very fetid animal oil, ammoniacal muriat, and a small quantity of phosphorus: its coal contains a small proportion of muriat of soda, or common salt. This analysis of urine shows, therefore, that it is composed of a large quantity of water, the disengaged phosphoric and lithic acids, muriat of soda, sulphat of lime, phosphat of lime, soda, and ammoniac, together with two peculiar extractive matters, which give the fluid its co-

lour. As to the deep colour it acquires in many disorders, and especially in all bilious affections, I have discovered, that it is produced by the resin of bile, and that its extract, dissolved by alcohol, is precipitated by water.

Urine, when exposed to the air, changes more quickly in proportion as the atmosphere is hotter. Depositions are first formed by simple cooling; several saline matters crystallize at its surface and bottom, and frequently a reddish salt, which appears to be of the nature of the calculus. No one has observed better the spontaneous changes of this excrementitious fluid than Hallé, my associate. He has distinguished, in the decomposition of urine left to itself, several terms or periods, which afford sediment or crystals of different natures, and are attended with various changes. Our present purpose not extending to the detail of all these changes, which are accurately described in an excellent Memoir, inserted among those of the Royal Society of Medicine for the year 1779, we shall confine ourselves to the principal alterations to which it is subject. Soon after it has become cold, its smell changes, becomes stronger, and indicates the presence of ammoniac; its colouring matter changes, and is separated from the rest of the liquor; lastly, this alkaline smell is dissipated, and is followed by another, less penetrating, but more disagreeable and nauseous; and the decomposition proceeds to its complete termination. Rouelle, the younger, has observed, that crude and ferous urine does not putrefy so quickly; that its smell, after it has become changed, differs greatly from that of the urine of concoction; and, lastly, that it becomes covered with mouldiness, like the juices of vegetables, and solutions of animal jelly. Hallé has observed certain urines which became very acid before they passed to the state of putrefaction. Urine, putrefied for a year, or more, affords fusible salt, as well as fresh urine; but it affords a much larger quantity of disengaged phosphoric acid, and effervesces with ammoniacal carbonat. The putrefaction extricates and drives off a part of the ammoniac. The salt deposited on the sides of the vessel, during evaporation, is strongly acid; and the quantity may be increased, by adding ammoniacal carbonat, according to the advice of Rouelle the younger, until the effervescence ceases, and the saturation of the acid is complete.

Quicklime, and dry fixed alkalis, immediately decompose the saline principles contained in urine. Nothing more is required, than to pour caustic potash, soda, or lime, into fresh urine, in order to produce an insupportable putrid ammoniacal smell. This is produced by the decomposition of the ammoniacal phosphat. Berthollet has discovered, that lime water, added to fresh urine, produces a precipitate, from which phosphorus may be obtained, by treating it in the same manner as calcined bones. This phenomenon depends on the union of the lime with the excess of phosphoric acid; and the precipitate consists of, 1. The calcareous phosphat, naturally contained in urine, and which was suspended merely by the excess of phosphoric acid; 2. An additional portion of calcareous phosphat, formed by the union of the superadded lime with the disengaged acid, together with that which is combined with the ammoniac. Berthollet having observed that caustic ammoniac likewise precipitates the calcareous phosphat of urine, by neutralizing the disengaged phosphoric acid which held that salt in solution, remarks, that the weight of this precipitate, compared with that produced by lime water, indicates the quantity of disengaged phosphoric acid contained in the urine; because, in fact, the ammoniacal phosphat, formed in this experiment, remains dissolved; whereas the calcareous phosphat, produced by lime water, being insoluble, is precipitated at the same time as the other portion of calcareous phosphat, which naturally exists in the urine.

Acids have no action on fresh urine, but they quickly take away the smell of putrefied urine, and of the depositions it forms in that state. Warm urine dissolves readily the sediment formed in urine by cooling.

Urine decomposes many metallic solutions. Lemery, distinguished by the name of the *rose-coloured precipitate*, a magma of that colour, which is formed when the nitric solution of mercury is poured into urine. This precipitate is partly formed by the muriatic acid, and partly by the phosphoric acid contained in this fluid. Brongniard has observed, that this preparation sometimes takes fire by friction, and burns rapidly on hot coals; he attributes this effect to a small portion of phosphorus.

Such is the present state of our knowledge respecting the chemical properties of urine. Much remains to be done, before we may esteem ourselves in possession of all that analysis is capable of discovering with regard to this fluid. It is necessary, for this purpose, to examine the different depositions observed in urine, and well described by Hallé, the red or transparent saline concretions which are formed, and which Scheele takes to be the lithic acid, should also be analysed, and the abundant sediment which urine affords after fits of the gout, in such as are attacked by the stone, &c.

In the following chapter we shall proceed to examine the peculiar saline products obtained from urine, to whose properties it is very necessary to attend.

NOTE ON CHAPTER VIII.

^a THE following experiments and remarks on urine, by Mr. Cruickshanks, are taken verbatim from Dr. Rollo's Treatise on Diabetes. They cannot fail to interest the reader, by the chemical information which they convey, and by the new views and conclusions to which they lead in medicine.

"The urine is a fluid separated from the blood by the kidneys, containing several neutral salts, with more or less animal extractive matter. The relative proportions of these substances are found to vary so much in the same person, both in health and disease, that it is extremely difficult to fix on what may be considered as a standard for healthy urine.

"The specific gravity of this fluid reaches from 1005 to 1033, that of distilled water being 1000; by exposure to the air, it soon runs into the putrefactive state, accompanied with the production of much ammonia, although when first voided, it always contains an excess of phosphoric acid, and reddens litmus; in consequence of this excess, it holds in solution more or less phosphat of lime, which may be readily thrown down by a fixed alkali, or even pure ammonia.

"By evaporation, 36 oz. yield a residuum, varying from 1 oz. to 1-one half; this consists of the muriats of potash and soda, the phosphats of soda, lime, and ammonia, the phosphoric and lithic acids, with animal extractive matter. Their relative proportions in a healthy state may be nearly as follows :

	Oz.	Dr.	Gr.
Muriatic salts,	-	-	0 1 0
Phosphoric salts,	-	-	0 3 50
Lithic acid and phosphat of lime, with excess of acid,	-	-	0 0 25
Animal extractive matter,	-	-	0 3 40

"The neutral salts, when purified by crystallization, are generally very fusible, but this circumstance varies much, according to the greater or less proportion of

phosphoric salts, more particularly the phosphat of ammonia, on which their fusibility in a great measure depends: instead of melting, this saline matter sometimes decrepitates when suddenly heated, owing to an excess of the muriatic salts; of these last it may be observed, that the muriat of potash is in general the most prevalent, and is easily distinguished from the muriat of soda, by its crystallizing in some degree by cooling, and by its affording cream of tartar on the addition of acid of tartar.

"In recent urine the ammoniacal salts bear a very small proportion; but when it has become stale or putrid, they are much more abundant. The phosphat of ammonia is the principal, although we have likewise met with the muriat of ammonia.

"The lithic acid and phosphat of lime are generally deposited, at least in a great measure, after the urine has become cold, and stood for some time; the quantity of the first varies exceedingly, but that of the last we have found, for the most part, nearly the same, the proportion being about one grain to two ounces.

"These substances may be easily distinguished, by dissolving them in twice their weight of nitrous acid, diluted with a little water, and evaporating to dryness; the dry mass when hot will assume a beautiful deep rose or crimson colour, when the lithic acid is present, but will continue white if heated even to redness, or have only a slightly greenish tinge when there is nothing but phosphat of lime. Their relative proportions may be ascertained by exposing the mixed mass for some time to a red heat in a crucible; in which case, the lithic acid will either burn out or evaporate, leaving the phosphat in a pure state.

"The quantity of extractive matter is more variable than that of any other substance; hysterical, or crude urine (as it has been called), containing hardly any, while that of concoction abounds with it.

"This matter yields, by distillation, water containing the carbonat of ammonia; this carbonat in a concrete state; a fetid empyreumatic oil; a little phosphorus; and, lastly, a residuum of animal coal, difficult to incinerate; in short, nothing more than the usual products from animal substances.

"If to an ounce of this extract, be added an ounce of the concentrated nitrous acid, diluted with an equal quantity of water, a violent effervescence, accompanied with heat, and the disengagement of nitrous gas will take place; when the action has ceased, and the liquor become cold, a number of shining scales, or crystals, resembling the acid of borax, will be deposited, which, when well dried on blotting paper, will be found to weigh from 5 to 7 drachms, or sometimes more, the proportion varying according to the quality of the extract, and the method of conducting the process.

"The figure of these scales appears to be that of flat rhomboids; they have a smooth greasy feel when pressed between the fingers; are soluble in much greater quantity in hot, than cold water, and also in some degree in alcohol; although repeatedly washed with this fluid, and dried on blotting paper, they still retain acid properties, and strongly redden the syrup of violets; they are readily taken up by the sulphuric and muriatic acids without commotion; but with the nitrous acid, they produce a kind of effervescence, and appear to be in some measure decomposed; they combine with the mild alkalis with effervescence, and form very soluble neutral salts, whose properties have not been sufficiently examined. Their solution in water does not precipitate lime water, nor the muriats of lime or barytes, nor the nitrats of silver or mercury, in any sensible degree, nor has it any effect upon the sulphat of iron or acetit of lead; they do not, therefore, contain phosphoric or oxalic acid; when thrown upon a red hot iron, they melt and evaporate in white smoke, leaving a very small quantity of a charry residuum, by no

means difficult to incinerate; but when exposed to an intense heat, they burn with a reddish flame, and a kind of detonation somewhat similar to the nitrat of ammonia.

"From these experiments it would appear, that this substance is an animal acid hitherto unknown, and whose basis exists in this extractive matter.

"We shall now briefly mention the effects produced by certain reagents on the urine, when in a healthy state, and likewise when altered by some morbid conditions of the body,

"Pure ammonia, and the fixed alkalis, dropped into healthy recent urine, produce a slight cloud, which on examination will be found to consist principally of phosphat of lime; about two grains may be obtained in this way from four ounces of urine. Lime water, likewise, throws down a precipitate which is much more copious, for reasons that must be obvious.

"Nitrous acid, added to healthy urine, produces a slight effervescence, and gives it more or less of a reddish colour, but produces no precipitation. In some diseases, however, particularly general dropsy or anasarca, this reagent when dropped into the urine, produces a milkiness, and in some instances a coagulation, similar to what would take place, if added to the serum of the blood. When bile is mixed with this fluid, as in jaundice, the acid renders it green; a similar effect is produced by the muriatic, and also in some degree by the sulphuric acids; for this purpose, however, the muriatic is to be preferred.

"The principal of tan, or infusion of oak bark, detects animal mucilage or jelly, and the quantity of coagulum thrown down will in general bear a certain proportion to the extractive matter. Four ounces of healthy urine afford in this way a precipitate of about four grains*.

"The corrosive muriat of mercury is a very useful reagent, as it has no immediate effect upon recent healthy urine, but in every case of increased action of vessels, more particularly of the inflammatory kind, a greater or less milkiness and a whitish precipitate is instantly produced; it likewise in some degree coagulates dropical urine.

"Effects somewhat similar, although not so striking, are produced by alum.

"The muriat of barytes detects the phosphoric salts. Four ounces of healthy urine yield with this reagent a precipitate of 13 grains, equivalent to about 24 or 25 grains of microcosmic salt, consisting of such a mixture of the phosphats of soda, and ammonia, as are usually met with in the urine. This substance will therefore show when these salts are deficient or in too great quantity. The sulphat of iron has a similar effect, but is not so certain, as any little excess of acid might prevent the separation of the phosphat of iron.

"The nitrats of mercury and silver are decomposed by the phosphoric and muriatic salts, and likewise, in some degree, by the extractive matter; they can therefore be but of little use as reagents.

"The acetit of lead is decomposed by the muriatic and phosphoric salts; with the last it forms an insoluble precipitate, but the muriat of lead may be dissolved by 18 or 20 times its weight of hot water. This circumstance affords a ready method of determining their relative proportions; for if we precipitate a given quantity of urine by this substance, dry the precipitate, and then digest it in 20 times its weight of distilled water, what remains must be phosphat of lead, and

* Seguin remarks that in every case where the action of the stomach and organs of digestion are much impaired, this infusion produces a copious precipitate.

the quantity taken up will indicate the proportion of muriat of lead. Four ounces of healthy urine, treated in this way, yielded a precipitate of 31 grains; this being digested in distilled water, 7 grains were taken up, the remaining 24 grains were found to be phosphat of lead, equivalent to 23 or 24 grains of microcosmic salt, as was determined directly by experiment.

"It must be observed, that the urine employed in these trials should be recent, and not kept for any length of time, as it is well known that ammonia is soon produced, which would render the results extremely uncertain. It was thought proper to give the quantity of precipitate thrown down by the principal reagents, when added to healthy urine, for by this means we shall be better enabled to detect any remarkable deviation from the healthy standard. The quantity of four ounces was conceived to be the most convenient, as in many cases we might not be able to procure more, and a less quantity could only afford uncertain results.

"Upon the whole, therefore, we would observe, that the proportion of extractive matter may, in some measure, be determined by an infusion of oak bark, or rather galls. The quantity of phosphoric salts by the muriat of barytes, or acetit of lead; that of the muriatic salts by the latter substance; the proportion of phosphat of lime by pure ammonia, or any of the alkalis, and the lithic acid by the process described.

"In morbid states of the urine, the coagulable part of the serum is detected by the nitrous acid, and even by heat; bile by the nitrous or muriatic acids; and the condition of urine accompanying rheumatism and other inflammatory complaints by the corrosive muriat of mercury, and sometimes by alum. With regard to sugar which is met with in Diabetes, the different methods of detecting it have been already fully explained; we would only further propose, when the quantity of saccharine matter is but small, that the extract obtained by careful evaporation should be treated with twice its weight of nitrous acid, and the whole reduced by evaporation to a very small compass; when this has become cold, the crystals formed should be carefully examined; if we perceive nothing but small cubes or rhomboids, we may be certain that no oxalic acid has been produced; but if along with these we should observe slender needles or prisms, these should be carefully separated, dried on blotting paper, and thrown into lime water; if a precipitation is occasioned, it must either be from phosphoric or oxalic acid, and from which may, in a great measure, be determined by the appearance of the precipitate; if this has the resemblance of flocks, and subsides slowly, the phosphoric acid is the precipitant; but if it has a powdery form, and subsides quickly, it must be produced by oxalic acid. To this mode we know it may be objected, that all animal substances yield more or less oxalic acid, but this is by no means true to the extent generally supposed, for there are several animal substances, and the extractive matter of healthy urine is one, from which we have never been able to procure any sensible quantity of this acid; of the different parts of the blood, the coagulating lymph is the only one which yields it in any remarkable proportion; and we believe that the coagulable part of the serum, when perfectly pure, does not afford it at all. We shall only further remark, that the method by fermentation, so much relied upon by some, is by no means correct, as will afterwards appear.

"From what has been delivered, it must be evident, than an attentive examination of the urine may lead to useful conclusions in several diseases.

"In dropsy the general disease may readily be distinguished from that depending on morbid viscera, by attending to the effects produced on this fluid by nitrous acid, and the corrosive muriat of mercury. In three cases which we have

lately met with, the urine coagulated not only on the addition of nitrous acid, but likewise by heat; and in one of them, which proved fatal in six weeks, the urine at one time appeared to differ but little from the serum of the blood, so remarkable was the coagulation produced both by heat and acids. This coagulable state, however, must not be confounded with that produced by cantharides, for we have seen some cases of violent stranguary from this cause, where the urine had the appearance of a mass of hydatids*.

"In the dropsy proceeding from diseased liver and other morbid viscera, the urine does not coagulate either by the nitrous acid or heat; it is usually small in quantity, high coloured, and deposits, after standing, a considerable quantity of a pink coloured sediment; this peculiar sediment we consider as, in some measure, characteristic of diseased, or rather schirrous liver. On examination, we found that it consisted of phosphat of lime, some animal matter, to which its red colour was probably owing, and a little lithic acid; this last, however, was in very small quantity.

"In inflammatory affections, particularly those of the chest and acute rheumatism, the urine, during the active state of the disease, always affords an immediate precipitate with the corrosive muriat of mercury or alum, and sometimes also with the nitrous acid; when the disease takes a favourable turn, this effect will in a great measure cease, and the lateritious sediment make its appearance.

"In fevers, particularly such as are accompanied with a strong action of vessels, similar phenomena may be observed; but, in this case, the lateritious sediment, which never fails to make its appearance at the crisis, or abatement of the disease, is much more remarkable and constant; and the nitrous acid, when added to the urine before the deposition takes place, gives a pretty deep red tinge.

"In gout too, the termination of the paroxysms is most perfectly indicated by a copious lateritious sediment, and when this suddenly disappears, and the urine at the same time affords a precipitate with the muriat of mercury, a fresh attack, or relapse, may be expected.

"We have examined several portions of this sediment, and have generally found it to be composed of lithic acid, phosphat of lime, and some peculiar animal matter, but little soluble in water; it has by some been supposed to consist entirely of lithic acid; but this substance, for the most part, constitutes by far the smallest part.

"In jaundice, the state of the disease may be ascertained by examining the urine, in which a very small quantity of bile may be detected by the nitrous, or muriatic acids, but more particularly the latter; when, therefore, the urine ceases to become green on the addition of these acids, we may infer that the obstruction to its passage into the duodenum is removed, and that, consequently, the yellowness of the skin, &c. will soon disappear.

"These spasmodic affections that take place in many nervous complaints, are immediately indicated by the urine, for, upon the approach of these, it will most generally be found very transparent, large in quantity, and abounding in saline, but containing hardly any extractive matter. Similar appearances have been observed to precede delirium in fevers. This state may be discovered by the infusion of oak bark, with which it will hardly give any precipitate, and by the acetit of lead, which will produce a very copious one.

* The infusion of galls likewise coagulates this species of urine.

"The necessity of attending to the different changes, which the urine undergoes in Diabetes, has been already sufficiently shown.

"In scurvy, and some other putrid diseases, as they have been called, we make no doubt the appearance and properties of this fluid are sufficiently remarkable, and we would recommend it to be examined by those who have proper opportunities.

"Can internal ulceration and suppuration be detected in this way?—In some diseases of the abdomen, accompanied with tumefaction, the urine has been met with of a white colour, as if mixed with pus; and in a few instances, when this change has taken place, the enlargement has suddenly subsided—Was this colour owing to pus, and if so, was the pus taken up by the absorbents, or was it carried off by the kidneys, in consequence of some direct morbid communication? In children, who are subject to worms, the urine has likewise been observed to have at times a white colour, and this has been supposed to proceed somehow from the chyle: this peculiar appearance is not to be confounded with what takes place in local affections of the kidneys and bladder, where it also occurs, but is sufficiently understood. We have had no opportunities of examining this kind of urine, and cannot, therefore, give any satisfactory account of it.

"We have thrown out these imperfect hints, merely with a view to induce others to pay some attention to a subject, which has of late been much neglected, but which, in our opinion, is capable of affording great assistance in the investigation, and cure of many diseases."

Fourcroy and Vauquelin have added greatly to our knowledge of urine, in a late memoir on that fluid. These chemists attribute the peculiar smell, taste, and colour of urine, together with the changes it undergoes from heat and putrefaction, to a substance which they term *urée*, or urinary matter.

Recent urine affords, by distillation, an ammoniacal water, and crystallized carbonat of ammoniac, long before it is wholly evaporated; the last portions of this water effervesce strongly with acids, and acquire a rose colour, which is scarcely changed by the air; the native acid of urine is then saturated, and flakes of animal matter deposited together with the earthy phosphats and the uric acid.

Urine shut up in close vessels becomes of a deep brown, or even black colour, emits a fetid ammoniacal smell, and deposits a slight cloud, which gradually forms mucous flakes more or less coloured. Small needle-shaped crystals, in regular prisms, or in silky tufts, are formed on the surface of the urine, or the sides of the vessels in which it is contained. The urine at this period is ammoniacal instead of being acid. Distilled to half its volume, it affords much fetid ammoniacal carbonat; distilled still farther, till it acquires the consistence of a syrup, it affords the acetit of ammoniac. The residue, from the evaporation of this putrid urine, does not afford the copious white concrete crystals which fresh urine does with the nitric acid, and which are owing to the unchanged urinary matter.

The ammoniac, carbonic, and acetous acids, formed during the decomposition of urine, are products of the urinary matter. They neither exist in fresh urine, nor can they be produced in urine which has already undergone putrefaction. In order that these substances may be produced, the presence of a certain quantity of gelatinous matter is required, which seems to act as a kind of ferment on the urinary matter; for urine, which contains a small portion of gelatinous matter, is little disposed to ferment or putrefy.

Human urine contains ten different substances, which are characterized in the following manner.

1. Muriat of soda, which in urine that has been evaporated, crystallizes in octahedrons.

2. Muriat of ammoniac, the natural octahedral form of which is changed into the cube, by its combination with the urinary matter, in the same manner as the muriat of soda is changed by this combination from the cube to the octahedron.

3. The acid phosphat of lime, which forms about 1-seven hundredth of the urine. It is precipitated by alkalis, which take from it the excess of acid.

4. Phosphat of magnesia decomposed by alkalis, and giving its earth mixed with the phosphat of lime, which is deposited, becoming a triple salt, its crystals separating by the spontaneous formation of the ammoniac.

5. Phosphat of soda, efflorescing in the air, always united with phosphat of ammoniac.

6. Phosphat of ammoniac, which is very scanty in fresh urine, increasing much by its decomposition, and by the formation of ammoniac. It affords phosphorus when the fusible salt of urine is heated with charcoal.

7. The uric, called very improperly the lithic acid. It crystallizes by the cooling of the urine, and forms the red sand which is deposited at the bottom of the vessels. It is most abundant in sick people, and is readily dissolved by alkalis in their caustic state.

8. The benzoic acid, which is most abundant in infants, is easily obtained from evaporated urine, by mixing it with one-tenth of concentrated sulphuric acid.

9. The gelatin and albumen are very variable in their proportion in different kinds of urine. They appear in the form of clouds in urine, in which ammoniac is formed, in that of filaments in urine, into which an alkali is poured, and in flakes in evaporated urine; they are precipitated by tannin, which serves to ascertain their proportion; and speedily produce putrefaction in the urine, which contains them in large quantity. They appear to be by their increase the primary cause of the formation of calculi, and to afford the gluten which holds the particles of the calculi together. The quantity of these substances in urine is in proportion to the strength or weakness of the digestive organs.

10. The peculiar urinary matter, which gives to urine its characteristic properties. It is the most abundant of the matters contained in urine, forming alone about 19-20ths of these matters. This urinary matter was considered, but improperly, as a saponaceous extract, by Rouelle the younger. It is to this matter that we are to attribute the almost complete crystallization of urine, which has been evaporated to the consistence of a syrup, the solid and crystalline form which it assumes in this state, by the addition of concentrated nitric, and the crystallization of the muriats of soda and ammoniac, modified, and in some measure inverted, the former passing from the cube to the octohedron, the latter from the octohedron to the cube.

Besides these ten substances, which may be considered as the true and constant materials of human urine, it sometimes contains, though seldom, and as it were by accident, sulphat of soda, muriat of potash, sulphat of lime, oxalat of lime, and filex. The two last seem to be very unfrequent products of some peculiar morbid dispositions in the urine.

The analysis of putrid urine differs greatly from that of fresh urine; not fewer than nine new matters are produced by the decomposition of the uric, or urinary matter. They are,

1. Ammoniac in excess.

2. Phosphoric acid, saturated with this alkali.

3. The phosphat of magnesia, changed into ammoniaco-magnesian phosphat.
4. Urat of ammoniac.
5. Acetous acid, combined with ammoniac.
6. Benzoic acid, saturated with ammoniac.
7. Muriat of soda, become octahedral.
8. Muriat of ammoniac become cubic.
9. Carbonat of ammoniac.

To these may be added the precipitation of the gelatin and albumen, produced by the ammoniac, and accompanying that of the phosphats; these salts, therefore, like the matter of the bones, become capable of affording carbon by heating them.

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CHAPTER IX.

CONCERNING THE AMMONIACAL PHOSPHAT, THE PHOSPHAT OF SODA, AND THE CALCULUS IN THE BLADDER, OR LITHIC ACID.

WE have seen that urine contains many peculiar salts; these salts are combinations of the phosphoric acid with ammoniac, soda, and lime, and the acid base of the calculus of the bladder. By following the methodical denominations already mentioned, we shall successively examine the ammoniacal phosphat, phosphat of soda, and lithic acid. We shall describe the properties of the calcareous phosphat when we treat of bones.

The salt, obtained by the cooling of evaporated urine, has been called *fusible salt* in general, because it melts in the fire, as we shall presently see; it has likewise been called *essential salt of urine*, or *microcosmic salt*: in this first state it is a mixture of ammoniacal phosphat, of the muriat and phosphat of soda, contaminated by an extractive substance. Several chemists, Margraaff in particular, supposed that it was necessary, in order to avoid the mixture of marine salt, that the urine should putrify; they imagined, that the marine salt became converted into a phosphat by the putrid action; a fact which is now known to be false. One hundred and twenty pints of urine, afford, according to Margraaff, about four ounces of ammoniacal phosphat, and two ounces of phosphat of soda. Though this proportion be variable, it is in general greater than Margraaff imagined.

The accurate separation of these two saline substances form the soluble salt obtained by a first crystallization, and which Shockwitz, le Mort, Boerhaave, Henkel, and Schlosier, considered as one and the same salt, is not easy. To effect this, the usual advice is to dissolve the fusible salt in hot water, evaporate the fluid, and crystallize it. But Rouelle the younger, and Chaulnes, are the only chemists who have mentioned a very great and singular difficulty presented in this process. The greatest part of the fusible salt is dissipated by the heat when the solution is evaporated; three-fourths being

lost by this means. Chaulnes has described a process for purifying it with the least possible loss; it consists in dissolving, filtering, and cooling this solution in well closed vessels; in either case, a salt, crystallized in very flat rhomboidal four-sided prisms, is obtained, which has been considered as pure ammoniacal phosphat; and above these first crystals, another salt, in cubes, or rather in long, square tablets, very different from the other, and which is the phosphat of soda: this last may be separated, according to the remark of Rouelle the younger, by removing its efflorescence from the former, which does not change. But each of these salts is a triple salt, the first is formed of a large proportion of ammoniacal phosphat, and a little phosphat of soda; in the second the order of the composition is inverted.

Of Phosphat of Ammoniac and Soda.*

I give this name to the pure crystallized salt which has been considered as purified ammoniacal phosphat, and which crystallizes first during the purification of the fusible salt. This salt has the form of very flat, rhomboidal tetrahedral prisms, which are often truncated lengthwise on their acute edges, by which they become converted into a kind of hexagonal prisms; there are likewise found, according to Romé de Lisle, from whom the present description of this salt is taken, longitudinal segments of these prisms, whose longest face resting on the vessel, has a rhomboidal form, and is intersected by two diagonal lines. The tetrahedral, and octahedral forms, attributed to this salt, are not met with, excepting when it contains much muriat and phosphat of soda: the muriat of soda appears more particularly to possess the property of modifying the form into that of an octahedron, since muriat of soda, dissolved in urine, and exposed to the sun, affords regular octahedrons at the end of some days. The taste of the phosphat of ammoniac, and of soda, is at first cool, afterwards urinous, bitter, and penetrating; when placed on a burning coal, it swells, emits a smell of ammoniac, and

* In a methodical nomenclature of the triple salts, the place of the words which denote the bases ought to indicate their reciprocal proportions; the base first named is the most abundant.

melts into a deliquescent vitreous globule, when urged by the blow-pipe. If distilled in a retort, very penetrating and caustic ammoniac is disengaged: the residue is a transparent glass, very fixed, and very fusible, which attacks the glass of the retorts. Margraaff affirms, that it is soluble in two or three parts of distilled water, and presents the characters of an acid. Rouelle affirms, that it is deliquescent. Morveau, on the contrary, thinks, that by means of heat it may be brought into the state of a permanent glass. Proust has discovered, that this vitreous residue is a combination of the phosphoric acid, with a portion of a peculiar matter, which he did not appear to be acquainted with, but which, from the inquiries of several modern chemists, has been found to be phosphat of soda. It must however be observed, that this compound glass is not obtained, excepting when ammoniacal phosphat, which still retains a portion of the phosphat of soda, is distilled, and that in this case the glass appears to be always either opaque, or very capable of becoming so, while very pure ammoniacal phosphat leaves a transparent glass, like the phosphoric acid alone.

The phosphat of ammoniac and soda is not changed by exposure to air.

It is very soluble in water, no more than five or six parts of cold water being required to hold it in solution. Hot water, at the temperature of 170 degrees, decomposes it, and even volatilizes a portion of its acid.

The phosphat of ammoniac and soda causes siliceous earth, alumine, barytes, magnesia, and lime, to enter into fusion; but these vitreous compounds are effected by the phosphoric acid, and the phosphat of soda, the ammoniac being driven off before the fusion takes place.

Lime, and the two pure fixed alkalis, decompose ammoniacal phosphat, and separate the ammoniac: If lime water be poured into a solution of this salt, a white precipitate is obtained, which consists of calcareous phosphat. The alkaline and earthy carbonats decompose it likewise, and separate the ammoniac in the form of ammoniacal carbonat.

The action of the mineral and the vegetable acids on ammoniacal phosphat has not yet been sufficiently examined. This action is referable to the various elective attractions

which exist between the phosphoric acid and its alkaline bases, we shall treat of them when we come to speak of that acid.

We shall likewise refer the alterations which the phosphat of ammoniac and soda is susceptible of, from metals and their oxyds, to the same part of our work, because those alterations absolutely depend on the phosphoric acid.

The phosphat of ammoniac and soda, treated with charcoal in close vessels, affords phosphorus. Bergman has proposed it as a flux in assays with the blowpipe.

Of Phosphat of Soda and Ammoniac.

We have already described the method of obtaining this triple salt. It was considered at first as a pure phosphat of soda, but in which there is always a little phosphat of ammoniac; it will be proper, in this place, to mention the several dates of this discovery.

Hellot appears to be the first who spoke of it, in the year 1737, but he took it for sulphat of lime. Haupt mentioned it in 1740, under the name of *sal mirabile perlatum*. Maargraff described it in the year 1745. Pott spoke of it in 1757; and, like Hellot, took it for sulphat of lime. Rouelle the younger, examined it particularly in the year 1776, and called it *fusible salt, with base of natrum*. All these chemists perceived the difference between this salt and the foregoing, to consist more especially in its not affording phosphorus with charcoal; but Rouelle has ascertained its properties better than any other chemist; according to him, its crystals are flat, irregular, tetrahedral prisms, one of whose extremities is dihedral, and composed of two rhomboids, cut in a contrary direction, the other end adhering to the base. The four sides of the solid, are two alternate irregular pentagons, or two long rhombuses.

The phosphat of soda and ammoniac, exposed to the fire in a crucible, melts and affords a white opaque-mass; when heated in a retort, it gives out a phlegm, which is slightly ammoniacal; its residue is a glass, or frit, which is rather more opaque than that of phosphat of ammoniac and soda.

This salt effloresces, and falls entirely into powder, by exposure to the air.

It readily dissolves in distilled water, and crystallizes by

evaporation; its solution converts the syrup of violets into a green.

Calcareous nitrat decomposes it, and affords a precipitate of calcareous phosphat: the supernatant liquor affords a nitrat of soda.

This salt is likewise decomposed by the nitric solution of mercury. It affords a white precipitate, which, distilled in a retort, produces a small quantity of reddish sublimate, with running mercury, and leaves at the bottom of the vessel a white opaque mass, adhering to, and combined with the glass. This mercurial precipitate, boiled with a solution of carbonat of soda, forms again the phosphat of soda, and leaves the mercury in the state of a brick-dust powder. All these facts were discovered by Rouelle the younger. Proust, at the instance of this celebrated chemist, whose pupil he was, made a considerable number of experiments, the principal results of which are the following. On lixiviating the residue of phosphorus, made with fusible salt of the first crystallization, from which no more than one-eighth of salt of phosphorus had been obtained, the lixivium by evaporation in the open air, afforded quadrangular crystals, of an inch in length, whose quantity, according to him, amounted to five or six drachms in the ounce of fusible salt employed in making the phosphorus. We must observe, that the quantity would not be so great, but on account of the water which enters into the crystals. This substance melts by fire into an opaque glass; colours flame green; effloresces in the air; decomposes the nitrats and muriats, by disengaging their acids; forms glasses with earthy matters by a melting heat, and saturates alkalis like an acid. From this examination, Proust thinks it different from all the saline substances known, that it was united with phosphoric acid and ammoniac in the ammoniacal phosphat, and that it formed with soda the fusible salt with base of natrum, of Rouelle. He observed, that it acted as an acid, and compared it to the boracic acid; and with this idea Proust made new experiments on the fusible salt of base of natrum, obtained by the process of Rouelle before described.

According to him, lime decomposes this salt, and has a stronger affinity with the peculiar substance, which serves the

purpose of an acid, than with soda. If lime water be poured into a solution of this salt, a precipitate is afforded, and the soda remains pure and caustic in the solution.

The mineral acids, and even distilled vinegar, decompose it by a contrary operation. Rouelle supposed that the sulphuric and nitric acids did not act on this salt, because they occasion no apparent change; but Proust having mixed the sulphuric, nitric, muriatic, and acetous acids, each separately, with a solution of fusible salt, with base of natrum, observed, that though no precipitate was afforded in these mixtures, the liquors by evaporation and cooling afforded sulphat, nitrat, muriat, and acetit of soda, which proves, 1. That this salt was decomposed by the acids. 2. That it contains soda, as Rouelle the younger had shown. As to the separate substance which was before united to the soda, it is evident that it remains in solution in the fluids, at the same time with the newly formed neutral salts. Proust has observed, that after the mixture of vinegar, and the crystallization of the acetit of soda, if eight or ten times its weight of alcohol be poured into the mother water, the last portions of the neutral acetous salt were dissolved, and a magma was formed, which he washed with new alcohol, and afterwards dissolved in distilled water. This solution of magma evaporated in the open air afforded crystals in quadrangular prisms, absolutely similar to those obtained from washing the residue of phosphorus made with the fusible salt obtained in the first crystallization of urine. This peculiar substance therefore, which resembles boracic acid, according to Proust, saturates the soda in the fusible salt with base of natrum. This discovery seems, in fact, to explain why it does not afford phosphorus. To these details, Proust added, that this new substance always existing in the true fusible salt, or phosphat of ammoniac and of soda, communicated to the phosphoric acid the property of melting into glass; for which reason I called it by the name of base of phosphoric glass, in the first edition of this work; but Morveau has since ascertained, that the pure phosphoric acid obtained by phosphorus falling into deliquescence, and consequently not containing this substance, melts alone by heat into a solid and permanent glass. The series of experiments which Proust made with great care,

and which is highly interesting in its results, induced Bergman to consider this substance as a peculiar acid, and he accordingly has given an account of it in the second edition of his *Dissertation on the Elective Attractions*, by the name of acid of sal perlatum, *acidum perlatum*, doubtless from the denomination given by Haupt in the year 1740, to the fusible salt with base of natrum. Morveau has since made it a particular article in his *Dictionary of Chemistry*, under the name of the *ouretic acid*, derived from the Greek name of urine which affords it. But since the time of the experiments of Proust, the *Dissertation* of Bergman, and the writing of the article by Morveau, Klaproth has published in *Crell's Chemical Journal*, an analysis of the fusible salt, with base of natrum, which destroys the existence of this pretended peculiar acid; and shows, that it is merely phosphoric acid combined with soda. Klaproth ascertained this fact by an experiment similar to that of Rouelle the younger; he precipitated the fusible salt with base of natrum, by calcareous nitrat, or muriat, the precipitate which Rouelle had before described as similar to the base of bones was found to afford phosphoric acid, by means of sulphuric acid. Klaproth adds, that by saturating the phosphoric acid, obtained by the slow combustion of phosphorus with soda, even to a small excess, a salt absolutely similar to the sal perlatum of Haupt, or to the fusible salt with base of natrum of Rouelle, is obtained; and that in order to produce the substance described by Proust, nothing more is necessary than to deprive this salt of the excess of soda by vinegar, or to add a small quantity of phosphoric acid. It is not therefore to be wondered at, after this discovery, that Bergman found absolutely the same elective attractions in the perlat acid, and the phosphoric acid. These facts have been stated by Morveau in a supplement to the acids of the animal kingdom; and he observes, that after this discovery, no further question will be made concerning either the ouretic acid or its salts. In addition to all these details, we have only to add farther, in order to render the history of this salt complete, that phosphat of soda always contains a little phosphat of ammoniac, and that this last salt acts a part in all the combinations into which it enters.

It is very singular that the phosphat of soda, is not decom-

posed by carbon, like the ammoniacal phosphat,—that carbon cannot deprive the phosphoric acid when in union with soda of its oxygen. Soda deprives this last acid of the property of being decomposed by charcoal, though it does not act in the same manner on the sulphuric, or other acids. This is a strong exception to the elective attractions of oxygen, and stands alone; it is equally remarkable, that the phosphoric acid added in excess to the phosphat of soda, leaves this compound, which constitutes, according to Klaproth, the peculiar substance of Proust, the property of converting syrup of violets to a green. Morveau adds to the history of phosphat of soda, that when a solution of the muriat of lead is poured into a solution of this salt, a precipitate of phosphat of lead is afforded, which when distilled with charcoal affords phosphorus, as Laumont, inspector of the mines, has discovered, with one of the ores of Huelgoet. Hence we may perceive, how the plumbum corneum proposed by Margraaff in the distillation of phosphorus of urine may augment the quantity of the product, as we shall explain in the following chapter of the lithic acid.

Concerning the Lithic Acid.

The calculus or stone which is formed in the human bladder, has long engaged the attention of physicians and chemists. Paracelsus, who gave it the barbarous name of *duelech*, supposed it to be formed by an animal resin, and compared it to arthritic concretions. Vanhelmont considered it as a concretion made by the salts of urine, and an earthy volatile spirit; and supposed that it differed from arthritic chalk, which was caused, according to him, by the thickening and acidification of the synovia. Boyle extracted from it oil, and much volatile salt. Boerhaave admits it to contain an earth united to volatile alkali. Hales obtained from it 645 times its volume of air, and out of 230 grains, the residue was only 49; he called it animal tartar. Many learned physicians, and especially Whytt and Deften, have considered alkaline matters as the true solvent of the urinary calculus: many have even proposed soap lees, but their conclusions were not founded on an accurate analysis of the calculus. Scheele and Bergman began this analysis; the former of these chemists discovered, that the stone in the

bladder is formed for the most part of a peculiar acid, which we call *lithic acid*. He obtained by distillation from 70 grains of the calculus in the bladder, 28 grains of this acid in a dry and sublimated state, some ammoniacal carbonat, and 12 grains of charcoal, very difficult to incinerate; 1000 grains of boiling water dissolved 296 grains of the same acid. This solution reddened blue colours, but the greater part of the acid separated by cooling, in the form of small crystals.

The concentrated sulphuric acid dissolves the calculus by the assistance of heat, and becomes converted into sulphureous acid. The muriatic acid does not attack it; the nitric acid dissolves it completely, nitrous gas and carbonic acid being disengaged during its action; this solution is red, and contains an acid at liberty; it dyes the skin, and other animal coverings of a red; no appearance of sulphuric acid is observed by the test of soluble barytic salts, nor of lime by the oxalic acid. Lime water forms a precipitate, soluble in acids without effervescence; caustic alkalis dissolve the calculus, according to Scheele. These solutions are precipitated by lime; 1000 grains of lime water dissolve 537, and ammoniac in great quantity likewise attacks the calculus. The same celebrated chemist affirms, that the brick coloured deposition of the urine of such as labour under fevers, is of the same nature. Though Scheele did not find lime in the stone of the bladder, Bergman obtained it by precipitating its nitric solution by sulphuric acid, and by calcining the residue of the same solution. Bergman has besides discovered in the calculus, a white spongy matter, insoluble in water, acids, and alkalis; the incinerated charcoal of this substance, whose quantity was too small to permit him to ascertain its nature, is not even soluble in the nitric acid.

From the analysis of these two celebrated chemists, which has been often repeated with the same results by different chemists, the calculus appears to be of a different nature from the earth of bones; yet Mr. Tennant, of the Royal Society of London, observed stones of the bladder which only lost two thirds by calcination, and whose residue melted into a glass, which became opaque by cooling, and consequently contained a very considerable quantity of calcareous phosphat.

As to the lithic acid, its properties, as far as they are

at present known, are, 1. A concrete and crystalline form: 2. Difficult solubility in water; and in much larger quantity in hot than in cold water: 3. That of being soluble by nitric acid, part of whose oxygen it absorbs, and then forms a reddish deliquescent mass, colouring many bodies: 4. It unites with earths and metallic oxyds, forming peculiar salts, which Morveau calls *lithiates* of lime, of potash, of soda, of copper, &c. 5. It prefers alkalis to earths: 6. It yields these bases to the most feeble acids, even to the carbonic, which is the cause of the insolubility of the calculus in the alkaline carbonats. This last character is peculiar to the present acid; however, there remains, as Morveau well observes, much to be done, respecting the lithic acid; to which I may add, that it remains to be ascertained whether it be not the modification of some other acid, as may be suspected from the known resemblance of the vegetable acids to one another, as well as between the pretended perlat or ouretic, and the phosphoric acid.

Morveau thinks, that the arthritic concretions, which physicians have supposed to be of the same nature as the calculus of the bladder, are very different from that substance; but he grounds his opinion only on certain experiments of Shenckius, Pinelli, and Whytt, which are far from possessing the accuracy at present required in experimental philosophy; and the observations of Boerhaave, Frederick Hoffman, Springfield, Alston, Leger, &c. on the good effects of alkaline waters, soap, and lime waters, on the arthritic and calculous affections, appear to me more proper to ascertain the existence of an analogy between these two kinds of concretions, than the former are capable of disproving it. It must, however, be allowed, as Morveau observes, that experiment alone is sufficient to decide the question, which affords an additional proof of the great importance of chemical researches in the art of medicine, and the advantages it promises to that useful science.

NOTE ON CHAPTER IX.

FOURCROY announces, that Vauquelin and he are at present engaged in the analysis of urinary calculi, and in the attempt to dissolve them by solvents that may be safely introduced into the bladder. Their first attempts are said to have been successful. They have discovered in urinary calculi,

1. Uric acid, or the lithic acid of Sheele.
2. Urat of ammoniac.
3. Ammoniaco magnesian phosphat.
4. Phosphat of lime, mixed with ammoniaco magnesian phosphat.
5. Oxalat of lime.
6. Silix.
7. An animal matter, of a very remarkable colour and texture. *Fourcroy, An. de Chem.* XXX. 54. XXVII. 225, 287. XVI.

CHAPTER X.

OF THE PHOSPHORUS OF KUNCKEL.

PHOSPHORUS is one of the most combustible substances we are acquainted with. As it was originally obtained from urine, and the substance which affords it in the greatest quantity, is the phosphat of ammoniac and soda, whose properties we have just examined, we think it proper to treat of the history of this substance in this place.

According to Leibnitz, the discovery of phosphorus is due to an alchemist named Brandt, a citizen of Hamburg, who discovered it in 1667. Kunckel associated with a certain person named Krafft, to purchase this secret; but the latter having purchased it, and refusing to communicate it to Kunckel, he resolved to make a series of experiments on urine, from which he knew it was extracted, in order to discover it. His inquiries were attended with success, and therefore he ought to be regarded as the true inventor. Some persons likewise attribute the honour of this discovery to Boyle, who in fact deposited a small quantity, in the year 1680, in the hands of the secretary of the Royal Society of London; but Stahl affirms that Krafft told him that he communicated the process of making phosphorus to Boyle: Boyle communicated his process to a German, named Godfreid Hanckwitz, who had a good laboratory at London, and was for a long time the only person who made phosphorus, and sold it to all the philosophers throughout Europe. Notwithstanding a great number of receipts for making phosphorus, and among others those of Boyle, Krafft, Brandt, Hoffman, Teichmeyer, Frederic Hoffman, Neiwentyt, and Wadeliuſ, have been published, ſince the year 1680; to the commencement of the preſent century, no chemiſt ſucceeded in preparing it; and the proceſs was in reality a ſecret, till a ſtranger, in the year 1737, offered at Paris to communicate a ſucceſsful method of making phosphorus. The Academy nominated four chemiſts, Hellot, Duſay, Geoffroy, and Duhamel, to attend this operation in the laboratory

of the Royal Garden. The process succeeded very well, the minister rewarded the foreigner, and M. Hellot described it very accurately, in a memoir inserted among those of the Academy for the year 1737. The operation consists in evaporating five or six hogheads of urine, till it is reduced into a granulated, hard, black, and shining substance; this residue is calcined in an iron pot, whose bottom is heated red hot, till no more fumes arise, and a smell like that of peach-blossoms is perceived; the calcined matter is lixiviated with about twice its weight of hot water, and is dried after the water has been decanted off. Three pounds of this matter are then mixed with one pound and a half of coarse sand, or pounded stoneware, and four or five ounces of the powder of charcoal of beech. This mixture being moistened with half a pint of water, is introduced into a Hessian retort; the matter is assayed, by making a portion red hot in a crucible: if it emit a violet flame, with a smell of garlick, is a proof that phosphorus will be afforded. The retort is placed in a furnace built on purpose, and a large receiver is adapted, one-third full of water; the receiver must have a small hole pierced in it; and M. Hellot considers this as one of the most necessary circumstances to ensure success. Three or four days after the apparatus has been put together, a fire is made, so as very gradually to dry the furnace and the lutes. The fire is raised by degrees to the most extreme heat, and kept up in that state from fifteen to twenty hours; the phosphorus does not come over till about fourteen hours after the commencement of the operation, which in the whole lasts twenty-four hours. A large quantity of ammoniacal carbonat first rises, which is partly dissolved in the water of the receiver: the volatile, or aeriform phosphorus, first passes in luminous vapours; the true phosphorus next comes over, in the form of an oil, or resembling melted wax. When no more passes over, the apparatus is left to cool for two days; the receiver is then unluted, and water is added to loosen the phosphorus adhering to the sides; the phosphorus is then melted in boiling water, and cut into small pieces, which are introduced into the necks of matrasses, cut towards the middle of the body in the form of a funnel, and plunged in boiling water; the phosphorus

melts, is purified, and becomes transparent, by the separation of a blackish matter, which rises to the top; it is afterwards plunged in cold water, by which it is congealed, and is thrust out of the necks of the matrasses by a small stick introduced at the lesser end. Such, in short, is the process described by Hellot. The length of the operation deterred chemists from repeating it, excepting Rouelle the elder, who performed it several times with success in his chemical lectures.

In the year 1743, Margraaff published, in the Memoirs of the Academy of Berlin, a new method of making a considerable quantity of phosphorus more readily than had been done before his time. According to his process, the plumbum corneum remaining after the distillation of four pounds of minium, and two pounds of ammoniacal muriat, is mixed with ten pounds of the extract of urine of the consistence of honey; half a pound of charcoal in powder being added, the mixture is dried in an iron pot till it is converted into a black powder; this powder is distilled in a retort, to obtain, by a gradual fire, the ammoniacal carbonat, fetid oil, and ammoniacal muriat. Care must be taken to urge the fire no more than till the retort is moderately red. The black and friable matter of this distillation is that which affords the phosphorus; it is assayed by throwing a small quantity on heated coals; if it emits a smell of garlic, and a blue phosphoric flame, it is a proof that it has been well prepared. An earthen retort of Hesse, or of Picardy, is filled to three-fourths of its capacity with this substance, well coated with lute; this vessel is placed in a reverberatory furnace, with a dome and iron chimney of six or eight feet in height; a middle-sized receiver, pierced with a small perforation, and half filled with water, is to be adapted, and the place of junction must be luted with fat lute, covered with fillets dipped in white of egg and lime; a brick wall is built up between the furnace and the receiver, and the whole apparatus is then left to dry for a day or two. The distillation is then begun, by a fire very gradually raised, and the operation lasts from six to nine hours, according to the quantity of matter exposed to distillation. The phosphorus is rectified by re-distillation by a very gentle heat, in a retort of glass, with a receiver half filled with water. Most chemists have repeated the

process of Margraaff with success; and it was the only process used, till the late discovery of separating the phosphoric acid from bones, as we shall observe when we come to speak of saline bodies.

It may be observed, that the process of Margraaff differs from that of Hellot only in the addition of the plumbum corneum, and the dividing the operation into two; but the most valuable part of the operation of the learned chemist of Berlin, consists in his determining which of the substances contained in urine serves to form the phosphorus. By distillation of a mixture of the fusible salt and charcoal, he obtained a very fine phosphorus, and observed that urine, from which this salt has been extracted, affords scarcely any of this combustible substance. It therefore follows, that phosphorus is formed by means of one of the constituent parts of fusible salt; and this substance is easily obtained, by distilling two parts of the glass obtained by this salt, decomposed in a retort or a crucible, with one part of charcoal in powder. This operation requires much less time, and a less degree of heat, than those we have before described, since, according to Proust, the phosphorus comes over at the end of a quarter of an hour. It is doubtless the best process for procuring the phosphorus of urine, but several objections may be made to it: 1. The vitreous residue of the decomposition of the ammoniacal phosphat by fire, not being the pure phosphoric acid, but combined with phosphat of soda, which is not decomposable by charcoal, the quantity of phosphorus obtained by employing this residue is but very small, since an ounce affords no more than a drachm, and frequently a less quantity. 2. Because, when a large quantity of fusible salt is obtained by evaporation and cooling, it is found to be mixed with a great quantity of the phosphat of soda, which does not afford phosphorus. It may, from these two observations, be conceived why so small a quantity of this combustible substance is obtained by the distillation of fusible salt with charcoal: fusible salt alone, of the mixture of the ammoniacal phosphat and phosphat of soda, distilled with charcoal and muriat of lead, or plumbum corneum, may perhaps afford a larger quantity, since the latter appears to have the property of decomposing phosphat of soda.

Phosphorus obtained by all the processes we have described, is always the same substance. When very pure it is transparent, and of a consistence resembling that of wax; it crystallizes, by cooling, in laminae, which are brilliant, and, as it were, micaceous; it melts in hot water, long before the fluid becomes boiling hot; it is very volatile, and by a gentle heat rises and comes over in the form of a thick fluid. When in contact with air, it emits a fume from every part of its surface; and this vapour, which smells strongly like garlick, appears white in the day-time, but is very luminous in the dark. The slow combustion of phosphorus consists in this disengagement, and if it be left for a certain time exposed to the air, it consumes by degrees, and leaves a peculiar acid, whose properties we shall hereafter examine. This slow combustion cannot be performed, unless the phosphorus be in contact with the air; and in order that it may be very luminous, a heat of from twelve to fifteen degrees of Reaumur's thermometer, or about sixty-three degrees of Fahrenheit's is required, though it takes place at a lower temperature. This inflammation does not produce heat, nor set any combustible body on fire^a; but when phosphorus is exposed to a dry heat, of twenty-four degrees of Reaumur, or 80 of Fahrenheit, it takes fire with decrepitation, burns rapidly, with a very lively white flame, mixed with yellow and green, and destroys all the combustible bodies it touches with the greatest facility. The vapours it emits are then very abundant, white, and very luminous in the dark. In a receiver full of vital air, this rapid combustion takes place with a very strong heat, and a brilliant flame. Phosphorus leaves a different residue in each of these combustions: the first affords a liquor, which weighs more than twice as much as the phosphorus made use of, and is known by the name of the *phosphorous acid*: the second gives a white, concrete, very deliquescent, and very soluble matter, which is the *phosphoric acid*; it then resembles the acid and fluid residue of the first combustion, or slow inflammation; yet these two acids present certain differences in their combinations, as Margraaff has observed, and as Sage has likewise pointed out, in the Memoirs of the Academy for the year 1777. We shall speak

more fully respecting these differences in the history of the two acids.

The combustion of phosphorus was considered by Stahl as the disengagement of phlogiston, which he supposed to be combined with the muriatic acid * in this inflammable substance. Lavoisier, in order to discover what happens in this combustion, kindled, with a red hot iron, phosphorus under a glass vessel, inverted over mercury; he observed that no more than a certain quantity can be burnt in a determinate bulk of air, and that this quantity consists of one grain of phosphorus for sixteen or eighteen cubic inches of air; after this combustion, the phosphorus is extinguished, and the air is no longer capable of burning new phosphorus; that the volume of the air is diminished, and the phosphorus dissipated in white snowy flakes, which adhere to the sides of the vessel. These flakes are twice and a half the weight of the phosphorus used, and this augmentation of weight corresponds exactly to that which the air has lost, and depends entirely on the absorption of oxygen by the phosphorus: in fact, the white flakes are the concrete phosphoric acid, formed by the combination of phosphorus with the oxygen, or the base of vital air, contained in the atmospheric air, which has served to burn this inflammable substance. This theory is the same as that of sulphur, and it is therefore unnecessary to repeat what has been said respecting this substance in the mineral kingdom. We shall only add, that of all combustible bodies, phosphorus appears to be that which disengages most caloric and light from vital air, and which absorbs the oxygen in the most solid state ^b.

Phosphorus is liquified in hot water. If vital air be passed through, phosphorus thus liquified, it burns, and is reduced to the state of phosphoric acid.

* Stahl has affirmed in several of his works, that by combining muriatic acid with *phlogiston*, phosphorus may be made. Margraaff made a series of experiments with different combinations of muriatic acid, treated with combustible bodies, and never succeeded in producing phosphorus; he has likewise shown, that the acid which remains after the combustion of this substance, differs very much from that of marine salt; and this is at present universally admitted by all chemists. *Note of the Author.*

Though phosphorus be not soluble in water, yet it is changed by it in process of time, and loses its transparency; becomes yellow, and covered with an efflorescence and coloured powder; the water becomes acid, and appears luminous when agitated in the dark; the phosphorus is therefore slowly decomposed.

The caustic fixed alkalis dissolve phosphorus, by the assistance of a boiling heat; during this combination, a fetid gas, discovered by Gengembre, which has the singular property of taking fire and exploding, by the contact of atmospheric air, and still more ready by the contact of vital air, is disengaged: this elastic fluid consists of phosphorus dissolved in hydrogen gas. Which last is produced by the decomposition of the water. We call it *phosphorated hydrogen gas*.

Sulphuric acid, distilled with phosphorus in a retort, burns it almost entirely, but without inflammation; the concentrated nitric acid attacks it with violence, and suddenly inflames it, provided the phosphorus be hot. When this experiment is made in a retort, with nitric acid not very concentrated, the phosphorus burns by degrees, seizes the oxygen of the nitric acid, and forms the phosphoric acid. This process was described by Lavoisier in 1780.

The muriatic acid does not attack phosphorus in a sensible degree, but the oxygenated muriatic acid burns it very readily. If phosphorus be dipped in oxygenated muriatic acid gas, it instantly kindles, and burns with deflagration.

The nitrats inflame it likewise, by the assistance of heat.

Sulphur and phosphorus combine, according to Margraaff, by fusion and distillation, and compose a solid substance, of a fetid odour, which swells in water, to which it communicates acidity, and the smell of alkaline sulphures; properties which certainly show a peculiar re-action between these two bodies, whose union seem to occasion the decomposition of water. Pelletier has observed, that sulphure of phosphorus, or phosphure of sulphur, denominations which indicate the reciprocal proportions of these two bodies, are infinitely more fusible than either of them taken separately.

Phosphorus does not unite so readily with metals as sulphur does, though it resembles that substance in many of its proper-

ties. Margraaff attempted to make these combinations, by distilling the several metallic substances, each with two parts of phosphorus: no peculiar phenomena were presented but by arsenic, zink, and copper; all the other metals were not changed by the phosphorus, which was partly burnt or sublimed in the receiver, without having experienced any remarkable change.

Phosphorus, sublimed with arsenic, afforded this celebrated chemist a substance of a beautiful red, similar to realgar.

Zink, distilled twice successively with this combustible substance, afforded yellow, pointed, and very light flowers; these flowers exposed to the fire under a red hot muffle, burned and afforded a transparent green glass, similar to that of borax.

Copper, treated in the same manner with phosphorus, lost its brilliancy, and became very compact; its weight was increased ten grains in the half drachm, and it took fire, and burned, on being applied to a flame. Pelletier has observed that copper combines very well with phosphorus, and that the result of this combination is a kind of grey, brilliant, granulated, very hard, and fusible ore. We give to these compounds, into which phosphorus enters without alteration, the name of *phosphures* of copper, zinc, arsenic, &c.

Pelletier, in his researches concerning metallic phosphures, has followed a very different method from that of Margraaff. To produce these combinations, he mixed the metals with vitreous phosphoric acid and a little charcoal; in proportion as the phosphorus is produced by the action of the charcoal, it combines with the metal. In this way he has been able to melt platina with the greatest ease, and to form a phosphure of platina, which serves to purify this useful metal.

Bouillon and Sage have described a remarkable alteration which phosphorus undergoes in metallic solutions: the first of these chemists has discovered, that small sticks of phosphorus, plunged in solutions of gold, silver, copper, &c. became gradually covered with a kind of sheath of shining metal: these valuable experiments show that the phosphorus has a stronger affinity with oxygen than many metals, and is capable of reducing their oxyds. Bergman has established the fact, that the

arsenic acid becomes black, and is converted to the state of arsenic, when heated with phosphorus, which becomes phosphoric acid, in proportion as it takes the oxygen from the arsenic.

Phosphorus dissolves in all oils, and renders them luminous. Spielman has discovered that it dissolves in alcohol, and that this solution emits sparks when it is poured into water: part of the phosphorus is precipitated in a white powder during this operation.

Phosphorus is as yet very little used either in medicine or in the arts. Menzies, Morgenstern, Hartman, &c. affirm, that they have experienced very happy effects in malignant and bilious fevers, when the strength has been exhausted, and in the biliary fever; others have recommended it in the scarlet fever, the peripneumony, rheumatic pains, epilepsy, &c.; but though several dissertations have already appeared in Germany on the medical virtues of phosphorus employed internally, nothing can yet be established concerning it, till experience has ascertained its virtues with greater certainty.

NOTES ON CHAPTER X.

^a VAN MARUM has discovered that this combustion of phosphorus takes place in rarified air, and that the light is increased in proportion as the air is more rarified. The phosphorus, in this instance, kindles when placed in a temperature not exceeding 56 or 58° of Fahrenheit, though it does not take fire in the open air, unless when heated to about 112°. In order to produce the rapid combustion it is necessary that a part of the phosphorus be surrounded with cotton, woollen, or some other very slow conductor of caloric. These substances, Van Marum conceives, act by confining the caloric; and accordingly he observed, that while the light round the phosphorus became stronger and stronger, the thermometer rose from 46 to 76° before the phosphorus began to take fire. *Ann. de Chim.* XXI. 158.

^b The experiments of Gottling, by which he endeavoured to prove the inflammability of phosphorus in azotic gas, are now generally allowed to have been inaccurate. The reader will find an ample refutation of these experiments in a small treatise, *Ueber das Leuchten des Phosphors in Atmosphärischen Stickgas von Scherer, Jäger and Pfaffs*, and in a Memoir by Fourcroy and Vauquelin in the twenty-first volume of the *Annales de Chimie*.

CHAPTER XI.

CONCERNING THE PHOSPHORIC AND PHOSPHOROUS ACIDS.

THE phosphoric acid has been thus called, because it has been thought to exist, ready formed, in phosphorus, from which it was obtained by combustion; but Lavoisier has proved, that this salt is a combination of phosphorus with oxygen. To obtain this acid, four processes may be used: the first consists in burning phosphorus rapidly, under glass vessels filled with atmospheric air, inverted over mercury; the combustion being begun, either by a burning glass, or a red hot iron wire, it is necessary first to moisten the inside of the glass with a small quantity of water. This process, directed by Lavoisier, affords phosphoric acid in a very short time, but mixed with a small quantity of phosphorus, not decomposed, that is, of acid in the phosphorous state: vital air may be used for this combustion, but the inflammation is then so rapid and violent, that it often causes the glasses to fly in pieces. This process affords pure phosphoric acid.

The second process, invented by Wolfe and Pelletier, is performed by passing a current of vital air through phosphorus melted under water.

In the third method, contrived by Lavoisier, phosphorus is burnt, by means of the nitric acid, rather more than moderately strong. Both these processes afford phosphoric acid.

The fourth process, or slow combustion, improperly called the formation of the phosphoric acid, *per deliquium*, is very well described by Sage. Sticks of phosphorus are placed in a glass funnel, whose neck is received in a bottle, and its base covered, but not closely; a tube of glass is put into the neck of the funnel, in order to prevent the phosphorus from falling through: and to give a passage to the air of the vessel, displaced by the phosphoric acid, care must be taken that the sticks of phosphorus do not touch each other, and that the temperature of the place does not exceed sixty degrees; as without these precautions, the phosphorus may deflagrate: By this method, an

ounce of phosphorus affords three ounces of an acid, which is collected in the bottle, with a small quantity of water, added by a little at a time. This is the phosphorous acid.

These four processes afford the acid of phosphorus in two different states, accordingly as it contains phosphorus not decomposed, or entirely burnt, and saturated with oxygen. These two acids exhibit phenomena, with respect to each other, similar to those exhibited by the sulphuric and sulphureous acids: This is the reason of the small difference between the results obtained by Sage and Lavoisier, in the combinations of this acid, as related in the Memoirs of the Academy for 1777. We call the first, or that in which the phosphorus is saturated with oxygen, *phosphoric acid*; and the second, which is not entirely saturated with oxygen, we call the *phosphorous acid*.

Of the Phosphoric Acid.

The pure phosphoric acid, obtained without addition of water, and in vital air, has the form of white, snowy, light, deliquescent flocks, of a very strong acid taste. By exposure to the air, it strongly attracts humidity. When placed in contact with a small quantity of water, it melts, or is dissolved easily, and affords a white fluid without smell, of an oily consistence, very ponderous, of a strongly acid taste, and rapidly converting blue vegetable colours into red. If it be exposed to the action of heat in a retort, pure phlegm is obtained; the acid becomes concentrated, and acquires a greater specific gravity than even the sulphuric acid, gradually becomes more consistent, loses its transparency, and resembles a soft extract: lastly, when urged by a violent heat, it melts into a hard, very electric, and insoluble transparent glass, which presents no character of acidity. It seems that this vitreous and solid state of phosphorus depends on a more intimate combination between the acidifiable base and oxygen, and the separation of part of the latter. This idea, respecting the more intimate adherence of oxygen in the phosphoric glass, which being no longer acid, merits the name of *vitreous phosphoric acid*, is confirmed by the difficulty of obtaining phosphorus from it by the addition of charcoal, and by the necessity of giving a high temperature to the mixture for that purpose.

If phosphoric acid, obtained by the slow combustion, or phosphorous acid be heated in an open vessel, small flames arise, from time to time, accompanied with the smell of garlick, which doubtless are produced by a portion of phosphorus not yet entirely burned. In these circumstances, the acid becomes concentrated and dry, and at last melts, in the same manner as when treated in a close vessel.

The concentrated phosphoric acid very quickly attracts the moisture of the air; it unites to water with heat, combines with a great number of substances, and presents peculiar phenomena in these combinations.

The liquid phosphoric acid does not appear to act on siliceous earth, according to the experiments of Bergman and Morveau; but it acts on glass, as appears from the experiments of Ingenhoufz and Priestley. When urged by the blow-pipe together with alumine, it boils; and the phosphoric acid, melted in Hessian crucibles, gives them a vitreous transparent glaze, as Morveau remarks ^a.

It unites with barytes, and appears to prefer it to all other bases, except lime, according to Bergman's table of attractions. The properties of barytic phosphat are not yet known ^b.

The phosphoric acid dissolves carbonat of magnesia with effervescence; the salt it forms with this substance is of difficult solubility; a well saturated solution, after twenty-four hours repose, affords crystals in very slender, small, flat needles, several lines in length, and obliquely cut off at each end; it often assumes the form of a transparent jelly; when exposed to a gentle heat, they become reduced to powder: the sulphuric acid decomposes this salt, according to Lavoisier ^c.

The phosphoric acid, poured into lime water, precipitates it in the form of a salt scarcely at all soluble, which does not effervesce with acids; it is decomposed by the mineral acids, but not by the caustic fixed alkalis. This salt is of the same nature as the base of bones. An excess of the phosphoric acid renders the calcareous phosphat soluble in water; but it is precipitated by magnesia, lime, caustic fixed alkali, and even by ammoniac, all which deprive it of its excess of acid. The calcareous phosphat is not decomposed by caustic alkalis, though it is by the carbonats of potash and of soda. The solid matter of bones is a superaturated phosphat of lime ^d.

The phosphoric acid, saturated with potash, forms a very soluble salt, which, by evaporation and cooling, affords tetrahedral crystals terminated by four-sided pyramids, whose sides correspond with those of the prisms: this phosphat of potash dissolves much more completely in hot than in cold water; it expands on hot coals, and melts but with difficulty: when melted, it loses its saline taste; it precipitates the nitric solution of silver, of a white colour, and that of mercury of a yellowish white: it is decomposed by lime water, which has a stronger affinity than potash to the phosphoric acid ^e.

Soda, united with the phosphoric acid, produces a salt of an agreeable taste, similar to that of the muriat of soda. The phosphat of soda does not crystallize; it is reduced, by evaporation, into a gummy deliquescent matter, tenacious and adhesive, like turpentine*. I have observed in this thick matter needles disposed in radii, which indicate a commencement of crystallization; but if a little more soda than is requisite for saturating the acid be added to this salt, a change of its properties is instantly effected; its taste becomes urinous; it changes the syrup of violets to a green; crystallizes in large parallelograms, and effloresces in the air. In short, it acquires all the properties of *fusible salt with base of natrum*, which is *super-saturated phosphat of soda*. This salt does not afford phosphorus with carbon, no more than the phosphats of barytes, lime, potash, and soda: Hence it appears, that the phosphorous acid must be in a disengaged state, in order to be decomposed by carbon^f.

Ammoniacal phosphat, formed by the combination of the phosphoric acid with ammoniac, is more soluble in hot water than in cold; and by cooling affords crystals, which, according to Lavoisier, resemble those of alum. I have observed that when the combination is accurately neutral, it is very difficult to obtain it crystallized, and that it almost totally evaporates by a gentle heat; but an excess of ammoniac favours the crystallization of this salt: a small quantity of the phosphat of soda produces the same effect, and in this state it is that we obtain it from urine. Barytes, lime, and alkalis decompose

* In England the phosphat of soda is prepared on a large scale, and sold in pharmacy in beautiful crystals, like sulphat of soda; it is used as a purgative.

the ammoniacal phosphat : fire readily disengages its ammoniac, and it is on this account that it affords phosphorus with charcoal^s.

The phosphoric acid decomposes the sulphat, the nitrats, and the alkaline muriats, by the dry way, and disengages their acids, by reason of its fixity ; but it yields its bases to them by the humid way.

The phosphoric acid, in its fluid state, acts only on a small number of metallic substances : it readily dissolves zink, iron, and copper ; these solutions do not afford crystals by evaporation, except that of iron, which appears capable of crystallizing ; the others are reduced into ductile and soft masses, resembling extracts : if they be urged by heat, they throw out sparks, and appear to form true phosphorus. Margraaff, and the academicians of Dijon, have examined fully the action of this acid on the metals.

The phosphoric acid likewise precipitates certain metallic solutions ; such as those of mercury and silver, by the nitric acid, in which it occasions precipitates.

The nitric and acetous solutions of lead are equally precipitated by the phosphoric acid, and by the soluble phosphats : the precipitate afforded by the decomposition of these last, or the phosphat of lead, affords phosphorus by distillation with charcoal.

This acid re-acts on oils, and exalts their smell ; to such oils as have no smell it gives a sweet, and as it were, ethereal smell ; it thickens some oils.

When distilled from charcoal, in its dry state, it affords phosphorus.

When heated in a retort with alcohol, it afforded the academicians of Dijon a liquor strongly acid, of a penetrating and disagreeable smell, which burnt with a small quantity of smoke, and exhibited some of the properties of ether. The phosphoric acid was rendered volatile in this experiment, and appeared from the acidity of the product, to have acquired the properties of phosphorous acid. Lavoisier has observed, that heat is produced in this mixture ; yet most chemists consider the phosphoric acid as insoluble in alcohol. Margraaff, Rouelle, Scheele, Wenzell, Laffone, and Chaulnes, have directed

the use of alcohol to purify and separate the phosphoric acid from the different foreign substances it may contain. Lastly, The phosphoric acid, holding in solution the phosphat of soda, affords, by fusion, a hard, insipid, insoluble, non-deliquescent, and opaque glass, similar to that afforded by fusible salt alone, when urged by the fire.

We must likewise observe, that the phosphoric acid, which was formerly supposed to be peculiar to urine, exists in many animal matters, as we have already seen, and will hereafter be pointed out. Margraaff discovered it in vegetables, and Berthollet has found it in all those which afford ammoniac by distillation. Mr. Hassenfratz has extracted it from a great number of plants which grow in the marshes, and from the earthy part of turf. It has been found in many minerals, and in particular in lead and iron, in which it seems to have been afforded by the decomposition of animal substances. Lastly, Proust has found it combined with lime, in a sparry stone from Spain; and Vauquelin has discovered traces of it in many calcareous substances.

Concerning the Phosphorous acid.

We have observed, that when phosphorus burns slowly, and does not become entirely saturated with oxygen; it forms an acid different from the former, and which has the same relation to it as the sulphureous has to the sulphuric acid, the nitrous to the nitric, and the acetous to the acetic acid: this diversity of the proportion of oxygen in this acid, causes a very great difference in its properties, as is observed in the other three acids. The phosphorous acid may likewise be considered as the phosphoric acid, holding a small quantity of phosphorus in solution. This acid assumes a fetid and disagreeable smell when it is rubbed, and especially when it is heated; part is volatilized in the form of a white vapour, which is very acute and penetrating: it is therefore much more volatile than the phosphoric acid; but this phosphorous acid never rises wholly in vapour like the sulphureous acid, and always contains a greater or less quantity of phosphoric acid, for which reason it leaves a vitreous residue, or melted phosphoric oxyd, when treated with a strong heat. It

may be prepared by decomposing the phosphoric acid, and there is always a certain quantity disengaged in the operation of making phosphorus. All the distinctive properties of the phosphorous acid have not been examined in detail; but those which have been observed, are sufficient to indicate the difference between this acid and the phosphoric acid. Sage, in the Memoirs of the Academy for the year 1777, has shown some of the characteristic properties of the phosphorous acids. According to this chemist, the salt which results from the acid obtained by the deliquium of phosphorus, when united to potash, or the phosphit of potash, is not deliquescent; the phosphit of soda is likewise crystallizable, and not deliquescent; the ammoniacal phosphit, on the contrary, attracts the humidity of the air^b.

NOTES ON CHAPTER XI.

Vauquelin has given a valuable memoir on the combinations of the phosphoric acid, in the *Journal de l'Ecole Polytechnique*. The following notes are taken from that memoir.

PHOSPHAT OF ALUMINE.

^a THIS salt is almost insoluble in water, but it becomes so by an excess of acid. It melts with the blow-pipe into a transparent glass, without undergoing decomposition. It is decomposed by alkalis, and by the other earths. Mineral acids produce the same effect.

PHOSPHAT OF BARYTES .

^b RESEMBLES, in many of its properties, the phosphat of lime. Like it, it is insoluble in water, indecomposable by alkalis and earths, decomposable by mineral acids, and even by some of the vegetable. It differs from it, however, in not being soluble in water, by an excess of acid, or by the addition of any other acid which does not decompose it.

Phosphat of barytes melts with the blow-pipe. If it be melted upon carbon it gives out a yellow phosphoric flame.

This salt may be formed either by uniting pure barytes, or the carbonat of barytes, immediately with phosphoric acid; or by mixing a barytic salt dissolved in water, such as the muriat, or nitrat, with the phosphat of potash, soda, or ammoniac. The phosphoric acid unites with the barytes, while the other salt remains dissolved in the water. Alkaline carbonats decompose the phosphat of barytes,

either cold or hot, but the carbonat of ammoniac is unable to produce the effect when heated. This salt has not yet been applied to any use. It may be employed with advantage to separate the sulphat of lime which adheres to the phosphoric acid obtained from bones. In boiling these substances together, the sulphuric acid unites to the barytes, and the lime to the phosphoric acid. By this process, two salts, perfectly indissoluble, are produced.

PHOSPHAT OF MAGNESIA.

^c I HAVE discovered a method of obtaining a speedy crystallization of this salt, in pieces of two or three inches long, and sometimes two or three lines of thickness. This method consists in mixing together equal parts of sulphat of magnesia, and phosphat of soda, dissolved in water. There is at first no apparent action between these two substances, but at the end of twenty-four hours, transparent prismatic crystals are formed, which vary in size according to the quantity of salts which have been employed.

This substance, when exposed to the air, soon loses its water of crystallization, and is reduced to a powder. It has no sensible taste, and melts easily with the blow-pipe into a globule, which preserves its transparency after cooling.

It is decomposed by the fixed alkalis, but not by ammoniac. On the contrary, magnesia decomposes completely the phosphat of ammoniac, particularly when assisted by heat. The phosphat of magnesia unites easily with ammoniac, and forms with it a very insoluble triple salt.

Lime and barytes decompose the phosphat of magnesia, as may be seen by pouring a solution of these earths into a solution of this salt.

The decomposition of this salt is effected by the mineral acids; they unite with the magnesia, and leave the phosphoric acid free in the liquor. It is decomposed also by the alkaline carbonats.

PHOSPHAT OF LIME.

^d THIS salt exists in great abundance in nature. It forms large masses in the mineral kingdom, and constitutes the basis of the hard parts in animal bodies. It is found too in small quantity in the ashes of vegetables.

This salt is rendered soft, or undergoes a kind of imperfect fusion by heat, which gives it the appearance of baked porcelain. Bones, however, exposed to the action of a very violent fire, give out a yellowish phosphoric light; but this is feeble, and very soon ceases. Perhaps it is owing to the small quantity of phosphat of ammoniac contained in the bony plates, or in the membranes which surround them. An excess of acid, or even the addition of the acetic acid, renders this salt soluble in water.

The mineral and oxalic acids produce only a partial decomposition of this salt. They take from the phosphoric acid only about 0.40 parts of the lime, with which it is combined.

In the process for obtaining phosphorus, hydrogen gas and carbonic acid are disengaged at the commencement of the operation; so that when the phosphoric acid begins to be decomposed, the hydrogen gas dissolves a small portion of the

phosphorus, and acquires the property of shining in the dark, when it comes into contact with the atmosphere. In this experiment, the carbon, in a high temperature, has a greater affinity for oxygen than the phosphorus. The phosphorus again seems to have a stronger affinity than the hydrogen, since the water is decomposed before the phosphoric acid.

The phosphorus is purified from the charcoal which it contains, by melting it in warm water, and passing it several times through chamoy leather.

PHOSPHAT OF POTASH.

^c IT is also decomposed by barytes. Some experiments seem to prove, that it is decomposed by soda, which appears to have a stronger attraction for the phosphoric acid than potash.

PHOSPHAT OF SODA.

^f THIS salt melts easily, and favours greatly the fusion of simple and compound earths, as well as metallic oxyds. It is on this account that it is much used in experiments with the blow-pipe.

It is decomposed by lime and barytes, and by calcareous, magnesian, barytic, and aluminous salts, in consequence of a double decomposition. The greater part of metallic oxyds are also decomposed by phosphat of soda. In this way, metallic oxyds may be speedily formed.

PHOSPHAT OF AMMONIAC.

^g THIS salt always accompanies phosphat of soda in animal matters. They seem to form a kind of triple salt.

It is decomposed by heat; the ammoniac escapes in the gaseous form, and the acid remains in the retort in a vitreous form. It produces the same effects with neutral and metallic salts as the phosphat of soda.

PHOSPHITS

^h HAVE many properties in common with the phosphats. They are distinguished from the phosphats, by affording, during distillation, a small quantity of phosphorus, and by emitting a lively light, when heated with the blow-pipe, even upon an incombustible support. They possess, in common with some other salts, the property of precipitating gold, in its metallic state, from its solutions, and of decolorating, by percussion, with oxygenated muriat of potash.

PHOSPHIT OF POTASH.

THIS salt crystallizes very readily by cooling, when the water in which it is dissolved is sufficiently evaporated. Its form appears to be a four-sided prism, terminated slopewise. Its taste is slightly penetrating. It is very soluble. Heated with the blow-pipe, it swells, and melts, without emitting, like the other *phosphites*, phosphoric light. It is collected, by melting it, into a transparent globule which crystallizes, and becomes opaque by cooling.

It is decomposed by lime and barytes, which produce copious precipitates in a solution of this salt. The sulphuric, nitric, and oxalic acids, &c. separate the phosphorous acid from its alkaline base, the oxygenated muriatic acid converts it into a phosphat.

It consists of Potash,	-	-	49,424
Phosphorous acid,	-	-	39,466
Water,	-	-	11,110

PHOSPHIT OF SODA

Is very soluble in water, requiring in the ordinary temperature of the atmosphere only two parts of that liquid to dissolve it. Its solution, when subjected to a slow evaporation, exhibits at first on the side of the capsules, small plumose crystals like those of sal-ammoniac; afterwards square laminae are formed on the surface of the liquor, which seemed to be formed by the union of four triangles. Some portion of this salt assume the form of the pappus, or down of some vegetable seeds; but in examining these with a good glass, they appear to be composed of a great number of small cubes, which come very close together, but do not unite, for we can easily see the space which separates them.

It decrepitates with the blow-pipe, and gives out a phosphorescent flame. It then melts into a glass, which spreads on the support, and becomes opaque by cooling. This salt consists of

Soda,	-	-	23,680
Phosphorous Acid,	-	-	16,320
Water,	-	-	60,000

PHOSPHIT OF AMMONIAC

HAS a very strong penetrating taste. It creeps up the sides of the vessels in which it is evaporated. It crystallizes in the form of very long fine transparent needles, so that it is difficult to determine by the sight alone, the form and the relation of its angles.

It boils up and swells with the blow-pipe, giving out after a few seconds, a great quantity of phosphorated hydrogen gas, which inflames in the air, and forms very beautiful circles of white smoke. This experiment proves, that phosphorus, in a high temperature, when assisted by the presence of ammoniac, possesses the property of decomposing water. The oxygen of the water, combines with one

portion of this inflammable substance, and its hydrogen with another portion, to form phosphorated hydrogen gas, which inflames as soon as it comes into contact with the air.

It is decomposed by distillation in a retort. The ammoniac is disengaged partly in a liquid state, and partly in the state of a gas, which retains phosphorus in solution, but which does not inflame. It gives out a phosphorescent light, when mixed with oxygen gas. What remains in the retort is vitreous phosphoric acid.

It is decomposed by potash, soda, lime, and barytes, for the solutions of these earths occasion a copious precipitation in that of phosphites of ammoniac. A strong smell of ammoniac is perceived during the action of the fixed alkalis. It precipitates nitrate of mercury, of a white colour, but the phosphite of mercury which results, soon becomes of a grey colour, particularly the part which is exposed to the light. It consists of

Ammoniac,	-	-	-	-	51
Acid,	-	-	-	-	26
Water,	-	-	-	-	23

PHOSPHITE OF LIME.

THE phosphorous acid forms with lime a very intimate combination, which is very insoluble in water, and which has no perceptible taste. It is rendered soluble by an excess of acid, and this triple union affords small hard and brilliant crystals, by a careful evaporation. These crystals are too small to enable us to determine their form. The phosphorous acid, appears to adhere strongly to the phosphites of lime, for it is impossible to separate it by frequent washings with water. This excess of acid is taken from it by all the earthy and alkaline substances, although these have for the phosphorous acid, less affinity than lime, which seems to prove, that the acid in this combination is retained by two different forces.

It melts with the blow-pipe, emitting a phosphorescent light, and forming into a globule, the transparency of which remains after cooling. Its fusion is promoted by an excess of acid, and the glass which it affords is more transparent. Lime seems to have, of all substances, the strongest affinity for phosphorous acid. It is decomposed by the mineral, and even by some of the vegetable acids, such as the oxalic, citric, tartaric, &c. It consists of

Lime,	-	-	-	-	51
Acid,	-	-	-	-	34
Water,	-	-	-	-	15

PHOSPHITE OF BARYTES.

IT is difficultly soluble in water. Lime water forms with the solution however, an evident cloud. The solubility of this salt, is greatly increased by an excess of acid, so that it affords by spontaneous evaporation fine needle-like crystals, so small indeed, that it is impossible to ascertain their exact form. The salt in this state, has the same habitudes with water, or the acidulous phosphite of lime.

The oxalic acid forms in its solution a crystalline deposit, composed of small and long needles. These crystals are a combination of oxalic acid and barytes: ammoniac takes the excess of acid from the phosphit of barytes, which is precipitated in the form of a white cloudy powder. This powder is soluble, like the phosphit of lime, in acetous acid, although this acid is unable to decompose these salts.

Phosphit of barytes melts with the blow-pipe into a globule, which is covered with so strong a light, that it is impossible to look at for a few seconds without injuring the eyes. This globule, which is transparent during fusion, becomes opaque by cooling. With the exception of lime, the earths and alkalis produce no change on this salt. The mineral, and several of the vegetable acids decompose it. It is composed of

Barytes,	-	-	51,230
Acid,	-	-	41,770
Water,	-	-	7,000

PHOSPHIT OF MAGNESIA.

THIS salt is slightly soluble in water, without the assistance of an excess of acid. It has no sensible taste, and effervesces in the air like phosphat of magnesia.

It swells suddenly with the blow-pipe; inflames and emits a greenish phosphoric light: it melts into a globule, which acquires a milky colour by cooling.

It is decomposed by the fixed alkalis, lime, and magnesia. Ammoniac produces only a partial decomposition, and forms with it, as with all other magnesian salts, a triple salt, possessing peculiar properties.

The sulphuric, nitric, muriatic, fluoric, citric, oxalic, and tartarous acids decompose it by disengaging its phosphorous acid.

The oxygenated muriatic acid converts it into a phosphat, by burning the small quantity of phosphorus which it contains. It consists of

Magnesia,	-	-	20
Acid,	-	-	44
Water,	-	-	36

PHOSPHIT OF ALUMINE.

It is very soluble in water, without an excess of acid, in which it differs from the phosphat, which is insoluble, and which becomes so only by an excess of acid. Evaporated with a gentle heat, it exhibits no mark of crystallization, no saline deposit; on the contrary, it forms a transparent ductile mass, which has a strong resemblance to a soft gum. This salt has an astringent taste. Placed on burning charcoal, it swells up like alum, and emits a beautiful phosphoric light.

It preserves the volume it acquired in swelling, and becomes very light and spongy. It does not attract humidity from the air, but remains dry and transparent. Alumine has the weakest attraction of alkaline and earthy matters, for phosphorous acid, so that it is easily decomposed. The greater part of acids decompose it.

Vauquelin remarks, that were we to judge by analogy of the properties of com-

compound substances, we should be led to believe, that the phosphites must be very combustible, as they contain a portion of unburnt phosphorus, which has so strong an attraction for oxygen, that it will unite with it in every temperature. But this is contrary to observation; for the phosphites remain for months, either in the liquid or solid state, without undergoing the smallest alteration. Sulphites, on the contrary, are in the same circumstances soon changed into sulphates. He ingeniously accounts for this difference, in the following manner.

The combustion of a body takes place more easily and speedily in conjunction with other bodies, which increase its affinity. It is in this way that metals dissolve much more rapidly in water mixed with an acid, than they do in pure water. It is on the same principle, that the nitric acid yields its oxygen to gold, when it is mixed with muriatic acid; though, if alone, it does not part with any, because the affinity of the nitric acid for the oxyd of gold is not sufficient to produce the decomposition of a part of the acid. It is therefore the pre-existing affinity of the oxyd of gold for the muriatic acid, which is very strong, that favours the oxydation of that metal. It is also in this manner in consequence of the greater affinity which alkaline and earthy bases have for the sulphuric and phosphoric acids, that these bases solicit, as it were, the sulphites and phosphites to absorb a fresh quantity of oxygen, in order to unite with their acids more closely or completely. But as the sulphuric acid has a much stronger affinity for alkaline substances than the phosphoric, the combustion of the sulphites must be more rapid than that of the phosphites. In addition to this, there seems to be a greater difference between the affinity of the sulphuric and sulphurous acid for the same substances, than between that of the phosphoric and phosphorous; the phosphorus in the phosphorous acid being in a state of much more complete combustion than the sulphur in the sulphurous acid; so that being surrounded by a great number of particles of oxygen, its affinity for this principle is proportionally diminished, and consequently the combustion of the phosphites is rendered less energetic.

CHAPTER XII.

CONCERNING THE SOFT AND WHITE PARTS OF ANIMALS AND
THEIR MUSCLES.

ALTHOUGH the analysis of the solid parts of animals be less advanced than that of their fluids, yet we begin to acquire some knowledge of the different matters which compose them; it is more especially ascertained that the difference between their texture or formation indicates a difference in their principles. This assertion will be confirmed by a comparative examination of the soft and white parts, with the muscles and bones.

All the soft and white parts of animals, such as the membranes, the tendons, the aponeuroses, the cartilages, the ligaments, the skin, contain, in general, a mucilaginous substance, very soluble in water, and not at all soluble in alcohol, which is known by the name of *jelly*. To extract this jelly, the animal parts must be boiled in water, and the decoction evaporated till it becomes a solid and tremulous mass by cooling; a stronger degree of evaporation affords a dry, brittle, transparent substance, known by the name of *glue*.

Glue is prepared with all the white parts of animals; the skin, the cartilages, and the feet of oxen, are used to prepare the strong glue of England, Flanders, Holland, &c. The skins of eels afford the base of gold size, and with old white leather gloves and parchment, a kind of glue used by painters, &c. is made. There are scarcely any animals, whose tendons, cartilages, nerves, and more especially the skin, will not serve to prepare these different kinds of glue.

It must be here observed, that glues differ from each other in their consistence, taste, smell, and solubility: there are some which readily become soft in cold water, others are not dissolved but in boiling water. The best glue is transparent, of a yellow brownish colour, without smell and taste, entirely soluble in water, with which it forms a viscid uniform fluid, that preserves an equal degree of tenacity and transparency in all its parts as it dries.

Animal jelly does not differ from glue properly so called, but

in its possessing a less degree of consistence and viscosity. The first is more especially obtained from the soft and white parts of young animals; it is likewise found in their flesh, muscles, skin, and bones. Glue is obtained only from animals of a greater age, whose fibres are stronger and drier. These two substances, however, exhibit the same chemical properties; and therefore we shall speak of the jelly afforded by the cartilages or membranes of veal.

In its natural state, jelly has no smell, and but a faint taste: by distillation in the water-bath, it affords an insipid and inodorous phlegm, capable of putrefaction; in proportion as it loses its water, it assumes the consistence of glue, and when entirely dried, it resembles horn; when exposed to a stronger fire, with access of air, it swells, liquifies, and becomes black, emitting an abundant fume, of a fetid smell; it does not take fire without exposure to a violent heat, and even then not readily; by distillation in a retort, it affords an alkaline phlegm, an empyreumatic oil, and a small quantity of ammoniacal carbonat; it leaves a large mass of charcoal, difficult to incinerate, which contains muriat of soda, and calcareous phosphat.

Jelly, when exposed to a hot and moist air, becomes first acid, and soon after putrid.

Water dissolves it in all proportions; acids, and especially alkalis, dissolve it readily; the nitric acid disengages azotic gas. Most of these properties show a resemblance between jelly and the insipid vegetable mucilages, if we except those of affording ammoniac by heat, and azotic gas by the nitric acid: and may not these last be attributed to a portion of albuminous matter, which the water extracts at the same time with the gelatinous substance, especially when jellies or glues have been prepared by strong decoction long continued^a.

The muscles of animals are formed of a parenchymatous and cellular substance, in which different humours are contained, partly concrete, and partly fluid. These humours are composed, 1. Of a red and white albuminous fluid. 2. Of a gelatinous mucilage. 3. Of a mild oil, of the nature of fat. 4. Of a peculiar extractive substance. 5. Lastly, of a saline matter, whose nature is but little known. The analysis of flesh, when distilled in a water-bath, affords an insipid water; and in a re-

tort an alkaline phlegm, an empyreumatic oil, and ammoniacal carbonat; which leaves a charcoal, from which a small quantity of fixed alkali, and muriat of potash or of soda, are obtained by incineration: these properties discover nothing which can be depended on respecting the nature of the principles. It is therefore necessary to have recourse to methods, by which these substances may be extracted without alteration, and afterwards examined separately.

Thouvenel, who observed these different substances, forced the fluids contained in the muscular sponge by pressure, coagulated the albuminous part by the action of heat, and obtained the salt by evaporation. He dissolved and separated the gelatinous mucilage by means of water, and used alcohol to separate the salts and extract from the jelly. The accurate separation of these different matters is, in general, very difficult; because they are all soluble in water, and alcohol dissolves the saponaceous extract, and a part of the salt at the same time. The process which succeeds best, appears to be the following: The flesh is first washed in cold water, which takes up the colouring matter with a part of the salt; the residue being digested in alcohol, gives out all the extractive matter, and a portion of salt to that menstruum. Lastly, the remaining mass being boiled in water, gives out its gelatinous part, and likewise those portions of extract and salt, which escaped the action of the former menstrua. By slowly evaporating the water first employed, without heat, the albuminous part coagulates, and is separated by the filter, and the saline matter may be obtained by a succeeding evaporation; the alcohol likewise being evaporated, affords the coloured extractive matter; and lastly, the decoction affords the jelly and the fat oil which swims at the surface, and fixes by cooling. After the extraction of these different substances, nothing remains but the fibrous matter, which is white, insipid, insoluble in water, contracts and curls up by heat, and by distillation in a retort, affords much ammoniac, and a very fetid oil. A large quantity of azotic gas is obtained from this substance by the action of the acid of nitre. In a word, it possesses the characters of the fibrous part of the blood; it there-

fore appears to be proved, that the muscular organ is the reservoir, in which the action of the vital powers deposits the fibrous matter, which becomes concrete by rest; and which appears to form the basis of that animal property which physiologists call irritability.

Nothing remains now but to examine the properties of each of the substances of which the flesh of animals are composed, in order to ascertain its nature with accuracy.

The albuminous matter, the jelly, and the fat part, are already known; the first perfectly resembles the serum of blood. We must observe, that it is this substance which, coagulating by the heat of water, in which animal food is boiled, produces the scum which is carefully taken off. This scum is of a dirty red brown, because the red colour is altered by the heat of ebullition. The jelly extracted from flesh causes soups, prepared with the flesh of young animals, which contains it in greater quantities than that of older animals, to assume the form of a tremulous mass. It is absolutely similar to that which constitutes the soft and white parts of animals, whose properties have been explained in the preceding article. The fat substance which forms the flat and round drops that float on the surface of broths and soups, and become solid by cooling, has all the characters of grease. It only remains, therefore, to examine the extractive matter, and the salt, obtained in the analysis of the muscles.

The substance which Thouvenel calls the mucous extractive substance, is soluble in water and alcohol; it has a strong taste, whereas jelly has none. When it is very concentrated, it is acrid and bitter; and it has a peculiar aromatic smell, which fire develops. This substance gives the colour to soups, as well as the taste and agreeable smell which are well known. When they are too much evaporated, or the quantity of flesh is too great in proportion to the water, soups are high coloured, and more or less acrid. The action of fire develops and exalts the taste of this extractive substance, so as even to give it the taste of sugar, or caramel, as is observed on the surface of roast meat, which is commonly called the *crisped part*. If we further examine the properties of this extractive substance when evaporated to dryness, we observe, that its taste is acrid,

bitter, and saline; that it swells and liquifies on hot coals, emitting a penetrating acid smell, similar to that of burnt sugar; that it attracts moisture when exposed to the air, and acquires a saline efflorescence on its surface; that it becomes sour, and putrefies in a warm air, when diluted with a certain quantity of water; and lastly, that it is soluble in alcohol. All these characters indicate a resemblance between this acid and the saponaceous extracts, and saccharine matter of vegetables.

The nature of this salt which crystallizes in the slow evaporation of the decoction of flesh, is not yet perfectly known. Thouvenel obtained it in the form of down, and that of irregular crystals. This chemist thinks that it is a perfectly neutral salt, consisting of potash, and an acid which has the character of the phosphoric acid in frugivorous quadrupeds, and that of the muriatic acid in carnivorous reptiles. Though this salt may be considered as unknown, till a sufficient quantity shall have been collected, to admit of its being examined with accuracy; yet it is very probable that it consists of phosphat of soda and ammoniac, and that even calcareous phosphat may be contained in it. These salts are indicated even with excess of acid, as in urine, by the test of lime water and ammoniac, which form white precipitates in the decoction; and the nitric solution of mercury, which affords a rose-coloured precipitate with the same liquor.

We may likewise add, that the most abundant substance, and that which constitutes the proper character of muscular flesh, is the fibrous part. This matter is deposited by the blood, which contains it in a large proportion, and is of great importance in the animal economy. Its nature and properties have not been sufficiently attended to in physiological inquiries respecting the quantity and weight of muscular flesh compared with the other organs. The characters which distinguish this animal matter are, 1. That it is not soluble in water. 2. It affords a larger quantity of azotic gas by the nitric acid, than any other substance, and afterwards affords the oxalic and malic acids. 3. It quickly putrifies when moistened, and affords much ammoniacal carbonat by distillation.

These properties show, that it is formed by a fat or oily

substance combined with azot, together with the phosphat of soda, and the calcareous phosphat, which are separated by the action of the nitric acid. I have considered the purposes which are answered in the animal economy by the fibrous matter, in a particular Memoir inserted among those of the Royal Society of Medicine.

NOTES ON CHAPTER XII.

THE most interesting property of the cellular jelly, is its tendency to combine with tannin. The compound of jelly and tannin, is a substance insoluble in water, and in alcohol, remarkably insusceptible of putrefaction; when dried, shrinking into a hard contracted mass, of a vitreous fracture; but, when thrown into warm water, becoming soft, tenacious, extensible, and in some degree elastic. *An. Chim.*

XXV. 225.

Seguin considers leather to be a compound of jelly and tannin, and consequently the art of tanning, to be the art of forming a proper combination of these two substances. He regards the cellular fibre as oxygenated jelly, which in that state cannot combine with tannin, but which acquires this property by passing to the state of jelly, in consequence of losing part of its oxygen. He has found, that substances capable of absorbing oxygen, deprive the cellular fibre of its solidity, and convert it into jelly. The art of tanning, according to these principles, depends on the united action of the gallic acid and tannin, both of which are present in tan. The gallic acid gradually decomposes the cellular fibre, abstracts from it oxygen in the same manner as it de-oxydates metallic solutions, and changes it into jelly. The tannin combines with this jelly as it is prepared, and forms with it leather. By this gradual operation, the felted texture of the skin is not destroyed, its flexibility and tenacity are preserved, while it is rendered impervious to water, and imputrescible. Skins swell and become soft in pure gallic acid, but are rendered hard and compact again in tannin. *Journ. Polytech. Cap. iv.*

Tannin has no action on the epidermis; hence, according to Chaptal, the advantage in the art of tanning, of destroying the epidermis by means of lime, before the skins be immersed in tan. The epidermis is insoluble in boiling water, and in alcohol. It is dissolved by caustic alkali, and by lime. *An. Chim.* XXVI.

221.

Consult on the art of tanning skins, *Ann. Chim.* XVIII. & XX. *Journ. Polytech. cap. 4. Nicholson's Journal*, l. xxvi. 271.

Tannin forms a precipitate in milk, serum, broth, and in the urine of dyspeptic patients. *Journ. Polytech.* It also precipitates jelly from its solution in sulphuric, nitric, and acetous acids.

Tannin also forms an insoluble coagulation in a strong decoction of lean flesh in albumen ovi, and in vitellus ovi. It preserves bile from putrefaction for several months, [but occasions no precipitation it, until an acid be added, when the

whole of the albuminous, and resinous part of the bile, is precipitated in combination with the tannin. *Ann. Chim.* XXX. 276.

^b This chapter seems the proper place for the chemical analysis of the brain, with respect to which, Fourcroy himself has published the only interesting experiments. *Ann. Chim.* XVI. 282.

The brain contains no uncombined alkali, as some chemists have asserted. The saline substances procured from it are in small quantity, and consist of phosphat of lime, phosphat of soda and ammoniac, and a little sulphat of lime.

No oil can be extracted from the brain by pressure, or heat, unless the heat be so great as to form an empyreumatic oil. This fact also is contrary to the assertions of former chemists.

Brain triturated with water, forms a white emulsive liquor, which passes through the filter and does not separate on standing.

This emulsion is coagulated by heat before it reaches the boiling point, but a small part of the medullary matter still remains dissolved in the water.

It is also coagulated by alcohol, and by acids, even when much diluted; but the transparent acid liquor, freed from the coagulum by filtering, retains a quantity of medullary matter in solution, which makes its appearance during the evaporation of the liquid. When sulphuric acid has been used, sulphurous acid gas is disengaged, carbonaceous matter is precipitated, and ammoniac is formed, which combines with part of the sulphuric acid. When nitrous acid has been used, nitrous and carbonic acid gas are disengaged; and when the liquor becomes more concentrated, an immense quantity of ammoniacal gas is extricated, and the residue of the animal matter converted into charcoal, and oxalic acid.

Brain heated in a water-bath, is separated into a transparent liquid, and a ductile salt coagulum. The weight of the coagulum, varies from 1-fourth to 1-fifth of the mass employed in the experiment. It is still diffusible in water, but subsides on standing.

Two ounces of this coagulum were boiled in successive portions of alcohol, till no more of it was dissolved. The residuum weighed 6 drachms. As the alcohol cooled, it deposited $2\frac{1}{2}$ drachms of a crystalline matter, which was soft and ductile, but did not melt at 212° , and in a higher temperature was decomposed. The alcohol was then allowed to evaporate in the sun. It left 3 drachms of a yellow substance, which had the softness of black soap, and was diffusible in water. This substance, like the former, did not liquify till decomposed by the heat; neither of them had any resemblance to spermaceti.

Brain, coagulated by heat, is also soluble in boiling olive oil, and in boiling oil of turpentine. It is also dissolved by potash, with a considerable disengagement of ammoniacal gas.

Coagulated brain, heated in an open crucible, became brown, and exhaled ammoniacal vapours; it afterwards melted, and became quite black. The vapours exhaled from it inflamed, and burned with a clear flame; some time after the flame had ceased, a small quantity of sulphureous acid gas was disengaged. The residue contained no alkali.

Recent brain, exposed to the open air at 60° , is very speedily decomposed, emits a very fetid smell, and evolves an acid. The existence of this acid was ascertained by a test paper, but its nature was not determined. It very soon disappeared, in the farther progress of putrefaction.

Recent brain, secluded from the contact of air, underwent no sensible decomposition in the course of a year, though kept in the temperature of 77° . During

the first days, a quantity of carbonic and gas was disengaged from it, but afterwards no elastic fluid made its escape.

The preceding experiments were made on the human brain. Similar results were obtained from the brain of the calf and sheep.

c The muscular flesh of young animals affords less azot than that of young animals, sometimes one third less. The flesh of carnivorous animals gives very little more azot than that of herbivorous animals. Fishes afford not more azot than quadrupeds, but part with it more readily, so that the azot appears to be less adherent in them to the other component parts of the fibre; and to this cause may perhaps be attributed their tendency to putrefaction. *Ann. Chim.* I. 40.

CHAPTER XIII.

CONCERNING THE BONES OF ANIMALS.

THE bones are the support of all the other organs of animals, the bases on which all the soft parts rest. These hard substances cannot be considered as passive in the animal economy, they are true secretory organs, which separate from the blood and other humours a peculiar saline substance, of which they are the reservoir, or place of deposition.

The bones in all animals, from man to insects and worms, differ in their texture, solidity, relative position, and probably in their nature. Chemical analysis has not yet decided respecting this last point; but it can hardly be supposed, that the bones of men and quadrupeds are of the same nature as the soft and flexible bones of fishes, reptiles, and more especially the corneous coverings of insects, as well as the calcareous shells of reptiles.

The general view which we shall here take of the bones of animals, does not permit us to dwell on such differences, as chemists have not yet sufficiently ascertained by experimental inquiry^a. The bones of men and of quadrupeds, which alone have been hitherto examined by chemists, are not earthy matters, as was formerly supposed: they contain a certain quantity of gelatinous matter, dispersed in small cavities, formed by the intervals between the solid parts which compose their texture; and the solid parts themselves, though they seem to resemble earthy substances by their insolubility and firmness, have been for several years past acknowledged to be a true neutral salt, consisting of phosphoric acid and lime.

Bones exposed to fire with the contact of air, quickly take fire, by virtue of a certain quantity of medullary fat which they contain. By distillation in a retort, they afford an alkaline phlegm, a fetid empyreumatic oil, and much ammoniacal carbonat; their coal is compact, and difficultly incinerated, and leaves a white residue, which, by washing in cold water, af-

fords a small quantity of carbonat of soda; hot water afterwards takes up a certain quantity of sulphat of lime: the residue of these lixivia is insoluble in water, and is the calcareous phosphat discovered by M. Gahn of Stockholm, in 1769. Bones calcined in a furnace in the midst of charcoal, remain luminous in the dark: by a strong heat they are semi-vitrified and reduced into a hard, very white, and semi-transparent kind of porcelain. This property appears to be owing to the phosphoric acid; it might be made the object of a particular art in pottery.

Water, in which bones, reduced into small pieces, or rasped, are boiled, becomes loaded with a substance which renders it viscid, and is a true gelatinous matter.

The alkaline carbonats decompose the calcareous phosphat, which forms the base of bones. This decomposition was discovered by the chemists of the academy of Dijon: they inform us, that they produced it by fusing a mixture of the powder of calcined bones, and carbonat of potash.

Acids act on bones, and decompose the calcareous phosphat they contain; by which means it was that Scheele, in the year 1771, succeeded in preparing phosphorus with bones. This chemist dissolved bones in the nitric acid, which seized the lime, and formed calcareous nitrat; the salt remaining in solution while the phosphoric acid was disengaged: On this mixture he poured sulphuric acid, which seizing the lime of the calcareous nitrat, formed sulphat of lime; this salt being precipitated on account of its insolubility, was separated by the filter. Lastly, he distilled in a retort the filtered liquor, which was a mixture of the nitric and phosphoric acids; and when the latter by the evaporation was reduced to the consistence of syrup, he mixed it with charcoal to obtain phosphorus. Poulletier and Macquer were the first who repeated these valuable experiments at Paris. Afterwards, the Academicians of Dijon, Rouelle, Proust, and Nicolas de Nancy, communicated their inquiries and processes. Many other chemists have examined the several solid substances of animals, and among the latter Berniard obtained phosphoric acid from fossil bones, from the bones of the whale, the elephant, the porpoise, the elk, the ox, and of the human species, the teeth of the sea cow, and the

grinders of the elephant ; and he observed, that all these bones afforded the same substances, and contained phosphoric acid in different quantities^b. Bullion has likewise obtained phosphoric glass from ivory, and from the bones of fishes.

The process of the chemists of Dijon and of Nicholas is at present mostly used to obtain the phosphoric acid from bones : the bones are calcined to whiteness, reduced to powder, sifted and mixed in a stone-ware pan, with an equal portion of concentrated sulphuric acid, a sufficient quantity of water being added, to give the whole the consistence of clear soup ; this mixture being left at rest for several hours, grows thick ; it is then poured on a filter of double cloth, and washed with water, till the fluid which passes through is tasteless, and no longer precipitates lime water ; in this case it is certain, that the residue contains no more disengaged phosphoric acid ; the filtered water being evaporated deposits gradually a white substance which is sulphat of lime, and must be separated by a filtration, care being taken to wash it with a sufficient quantity of water to carry off the phosphoric acid that may adhere to it. These filtrations are to be repeated till the fluid deposits no more precipitate : it is then evaporated to the consistence of honey, or a soft extract, and at that time has a brown colour and greasy aspect. If this be gradually heated in a crucible till it ceases to emit a sulphureous, and as it were aromatic smell, and no longer boils, it acquires a semi-vitreous consistence with an acid taste, and attracts the humidity of the air : a greater degree of heat fuses it into a transparent, hard, insipid, insoluble glass, which has no acidity. When phosphorus is intended to be made, it is not necessary to continue the heat till the residue becomes converted into the form of an insoluble glass, because it then would not afford phosphorus, but by a strong heat and much less readily, than while it is still soft and deliquescent. To convert it into phosphorus it is pulverized, mixed with one third of its weight of very dry charcoal, and the mixture introduced into an earthen retort, to which a receiver half filled with water, and pierced with a small aperture, or terminating in a syphon connected by the apparatus of Woulfe is adapted ; the fire is raised by degrees till the retort is heated to whiteness, at which time the phosphorus passes

over in drops, and the operation lasts from seven to twelve hours, according to the quantity of the matter distilled, and the heat the furnace is capable of giving. From six pounds of bones, twenty ounces, or a little more, of the vitriform residue is usually obtained; and this residue affords about three ounces of very good phosphorus, and a few drachms of phosphorus half decomposed. If it is only intended to prepare phosphorus, from the phosphoric acid of bones, the acid must be evaporated to the consistence of an extract, and distilled with charcoal: phosphorus is obtained by this process much more readily.

This product obtained from bones by the sulphuric acid, as well as the residue of the ammoniacal phosphat, decomposed by fire, does not consist of the pure phosphoric acid, since it affords at most one-fifth of its weight of phosphorus: it appears to contain a certain quantity of phosphat of soda. If this salt remains mixed with calcareous phosphat, arising from a small quantity of sulphat of lime, it usually melts with the phosphat, and forms a very hard opaque glass, which resists the action of all menstrua.

Morveau has proposed a method of obtaining very pure ammoniacal phosphat, with the phosphoric acid of bones; for this purpose, calcined bones must be dissolved in the diluted sulphuric acid, and the solution assayed by that of bones in the nitric acid, in order to be sure that no disengaged sulphuric acid remains, the portion of calcareous phosphat it contains is precipitated by the caustic ammoniac, as Wiegleb practises in his process; after which the liquid is filtrated, and suffered to evaporate spontaneously. Very beautiful crystals of ammoniacal phosphat are obtained, mixed with a small quantity of phosphat of soda, which separates by efflorescence. The calcareous phosphat, which remains on the filter, may be decomposed for the making of phosphorus^c.

NOTES ON CHAPTER XIII.

^aM. HATCHETT lately read before the Royal Society some curious observations on shell and bone, containing a variety of new and interesting matter. The following is the general plan on which his experiments were conducted: The substance to be examined was immersed in acetous acid, or in diluted nitric or muriatic acid, and no heat was applied. The dissolved portion was examined by caustic ammoniac, and afterwards by the carbonat of ammoniac or potash. The caustic ammoniac served to precipitate the phosphat of lime when present, and the carbonats separated carbonat of lime. If any other phosphat was suspected, the solution was tried by the acetit of lead. The following are some of the principal results from his experiments.

In porcellaneous shells, such as various species of voluta, cypræa, and others of a similar nature, no traces could be discovered of phosphat of lime, nor of any other combination of phosphoric acid; and from many experiments it appeared, that these shells consist of carbonat of lime, cemented by a very small portion of animal glue.

Some patellæ from Madeira were next examined. These were found to contain a larger portion of a more viscid, gelatinous substance than the preceding, but otherwise afforded nothing but carbonat of lime.

The shell of the common oyster resembled the patellæ, only the gelatinous part was rather of a greater consistency.

The shell of the river muscle was evidently composed of a series of membranes, applied *stratum superstratum*, and incrusted with calcareous matter, which was found to be carbonat of lime. Much less carbonat of lime was obtained from this shell than from those already mentioned. The quantity of animal matter was proportionably greater.

The haliotis, iris, and turbo olearius, resembled the shell of the muscle, both in their membranous structure, and chemical composition, excepting that their membranaceous parts were more compact and dense.

Similar experiments were made on naire, or mother of pearl, brought from China, and on pearl. Both were found to have the lamellated structure and composition already described.

The cuttle bone of the shops were found, in composition, exactly similar to shell, and consists of various membranes hardened by carbonat of lime, without the smallest mixture of phosphat.

Some traces of phosphat of lime were found in the common garden snail, but none in the helix hemoralis.

The crust of the echini contains phosphat of lime, but a much greater quantity of carbonat.

When the asterias was immersed in acids, a considerable effervescence was produced, and a thin external stratum was dissolved, after which it remained in a perfectly coriaceous state, and complete in respect to the original figure. The

dissolved portion proved, in one species of afterias, to be carbonat of lime without any mixture of phosphat; but, in another species, a small quantity of phosphat was discovered.

Mr. Hatchett next proceeded to the decidedly crustaceous animals, and examined the crabs, lobster, prawn, and cray fish. His experiments were afterwards directed to the bones of fish and quadrupeds.

The coverings of the crustaceous animals resemble the bones of quadrupeds, in being formed of a calcareous part soluble in acids, and of an animal membranous part, which becomes soft and elastic, but retains its original figure after its calcareous incrustation is dissolved. The calcareous part consists of carbonat and phosphat of lime; but the former is in the largest proportion.

The bones of fish, such as those of the salmon, mackerel, brile, and skate, afford phosphat of lime, and differ from those of quadrupeds, only in containing a larger proportion of membranous or cartilaginous substance.

Bones, besides phosphat of lime, contain carbonat of lime, and a small quantity of sulphat of lime.

When human bones, or teeth, as well as those of quadrupeds and fish, whether recent or calcined, are exposed to the action of acids, an effervescence, though at times but feeble, is produced. The gas, received in lime water, is speedily dissolved, and a proportionate quantity of carbonat of lime is precipitated. After the solution of bone in acids has had the whole of its phosphat of lime precipitated by ammoniac, a small quantity of carbonat of lime is still separated by any alkaline carbonat.

The solution of bone in nitric acid affords a small quantity of precipitate into nitrat of barytes.

The enamel of the teeth dissolves in acids without losing any residue, and burns with little or no smoke, and hardly any smell of burned horn. Mr. Hatchett compares it to the porcellaneous shell, with this difference, that enamel consists of phosphat of lime in place of carbonat.

Horns, such as those of the ox, the ram, and the chamois, also tortoiseshell, afford, after distillation and incineration, so very small a residue, of which only a small part is phosphat of lime, that this last, in Mr. Hatchett's opinion, can scarcely be regarded a necessary ingredient. 500 grains of the horn of the ox left only 1.5th grain of residue, and of this less than half proved to be phosphat of lime: 78 grains of the horn of the chamois left only 5 grains of residue; and 500 grains of tortoiseshell yielded not more than 25 grains, of which less than half was phosphat of lime.

Pure membrane contains very little phosphat of lime: 250 grains of a dry hog's bladder was reduced, by incineration, to 0.2 grains. This was dissolved in diluted nitric acid; and, upon adding pure ammoniac, some faint traces of phosphat of lime were observed.

Fossil bones contain phosphat and carbonat of lime, having derived the carbonat chiefly from the surrounding strata. They resemble calcined bones in wanting the membranous, or cartilaginous part; yet, it appears in some instances, that ages are insufficient to effect the spontaneous decomposition of this substance. *Pb. Trans. Part II. for 1799.*

It may not be improper to add a few miscellaneous facts to the interesting observations of Mr Hatchett.

Herissant has anticipated Mr Hatchett in his account of the alternate layers of membrane and calcareous incrustation, which constitute the shells of many of the testacea. Herissant's interesting observations on this subject are to be found.—*Mem. Ac. Sc.* 1766.

Rouelle and Bernard also preceded Mr Hatchett in their examination of the oyster-shell, and naire de perle, and, like him, found in these substances no traces of phosphoric acid. *Journ. Phys.* XVI. 373.

Bernard also examined a fossil tooth of the elephant. He got from it no oil, or ammoniac, but phosphoric acid and lime as usual. *Ib.* XIX. 50.

Giobert of Turin has examined a variety of fossil shells, and obtained from the greater part of them phosphoric acid. What is singular enough, he procured this acid from ostreites and volutites, though Mr. Hatchett got none from the ostrea or voluta. Some very small cornua ammonis afforded Giobert no appearance of phosphoric acid. He dissolved them in nitric acid, and added to this a solution of iron, but no phosphat of iron was precipitated. The same happened with some small turbinites and tubulites. *Mem. Ac. Sc. Turin*, IV. 38, 73.

At different times I have calcined quantities of pure cartilage, obtained from the cartilaginous extremities of the ribs in the calf. The fixed residue, after calcination, never exceeded 0.1.

The cartilaginous bones of the skate leave 1-8th of fixed residue, by far the greatest part of which is phosphat of lime, and the rest carbonat.

It appeared in some trials, that in the calcareous covering of the lobster, after calcination, the proportion of phosphat to carbonat of lime, was nearly 1 to 3. In a human bone, under the same circumstances, the case was reversed; the phosphat exceeding the carbonat in the proportion of rather more than 3 to 1. In these experiments, the bones were calcined, and the residue dissolved in nitric acid, from which the phosphat of lime was precipitated by ammoniac, and carbonat of lime by carbonat of potash. Both phosphat and carbonat were dried in a heat equal to that of a water-bath, before they were weighed. The quantity of carbonat of lime in recent bone is very small; the greater part of the lime, which was procured in the state of carbonat by the preceding experiments, having existed in recent bone in combination with phosphoric acid, forming phosphat of lime with excess of lime.

^b The following table shows the quantities of phosphoric acid glass, of lime and soda, which Bernard obtained from the under mentioned substances. The lime is calculated on the supposition, that sulphat of lime contains 32 of lime; but, that no mistake might arise from this circumstance, the sulphat of lime procured from the decomposition of the bone by sulphuric acid, is put down. The soda was extracted from the bone when in the state of a grey calx, before its complete incineration.

Grains.	Phosphoric acid glafs.	Lime.	Sulphat of lime.	Soda.
	grains.	grains.	grains.	grains.
10368 Elk's horn afforded	1800	3087	9648	35
Tooth of the sea cow,	1800	3179	9736	None--but seven grains of muriat of foda.
Tibia of the ox,	1512	3283	10260	
Os ilium and sacrum of man,	1440	3046	9518	89
Jaw-bone of porpoise,	1440	3064	9576	{ 39, and nine grs. muriat of foda.
Rib of whale,	1368	2890	9031	
Bone found at Paris, and supposed to be the head of one of the calcareous animals,	{ 1260	{ 2969	{ 9484	{ 51
Vertebra of the elephant,				
Grinder of the elephant,	972	2684	8388	None.
Large tooth found on the banks of the Ohio,	{ 720	{ 2866	{ 8956	None.

Journ. Phys. XVIII. 278, 299.

c When the powder of calcined bones is digested for a long time in a solution of sulphat of ammoniac, a double decomposition is effected; sulphat of lime is formed, and phosphat of ammoniac is found dissolved in this liquid. *Ann. Chim.* VI. 37.

CHAPTER XIV.

CONCERNING DIFFERENT SUBSTANCES USED IN MEDICINE AND THE ARTS, WHICH ARE OBTAINED FROM QUADRUPEDS, CETACEOUS ANIMALS, BIRDS, AND FISHES.

IF we proposed to make an accurate and ample history of all the substances afforded by animals, and applied to medical purposes, or used in the arts, it would occupy more of our time than has already been applied to the animal kingdom, more especially if we were to treat of the animal matters, which empiricism, or ignorant credulity, have formerly introduced into medicine as celebrated remedies, but which at present are regarded as entirely useless. We do not, however, propose to mention more than the principal of these substances, which medical and chemical experience has shown to possess more valuable properties, or which are of the greatest utility in the arts.

Among the matters afforded by quadrupeds, we select castoreum, musk, and hartshorn; ambergrise, and the white substance produced by a cetaceous animal, which is known by the name of spermaceti, will be treated of apart. Among the products of birds, we shall exhibit the analysis of eggs; among oviparous quadrupeds and serpents, the tortoise, the frog, and the viper, will claim a separate article. Ichthyocolla, or isinglass, is the only product of fishes which we shall consider. The class of insects will afford a greater number of objects: cantharides, ants, millipedes, honey, wax, the silk worm, and silk, gum lac, kermes, cochineal, and crabs eyes; and lastly, we shall conclude our examination of the products of the animal kingdom, by that of coral and corallines, which belong to the class of worms and polypi.

From this short enumeration, it will be seen, that we pass over in silence a great number of other matters, formerly used in medicine; such are, among others, ivory, unicornu, the teeth of the hippopotamus, of the beaver, of the boar, the bones of a stag's heart, the feet of the elk, bezoar, civit, and

nest, goose grease, peacock's dung, and the membrane of the stomach of poultry, among birds; the toad, and the scincus, among oviparous quadrupeds; the gall and stones of carp, the liver of the eel, the stones of perch, the jaws of the pike, among fishes; the scarabæus, spider's web, the meloe, or profcarabæus, and the claws of crabs, among insects. Lastly, shell-worms, snails, oyster-shells, nacles of pearl, and bones of cuttle-fish, among the naked, or covered worms. Among all these substances, some have only imaginary virtues, and others are well supplied by those we have chosen, and which we shall proceed to examine.

§ I. Of *Castoreum*.

The name of *castoreum* is given to two bags, situated in the inguinal region of the male or female beaver, which contains a very odourous substance, soft and almost fluid when recently cut from the animal, but which dries, and assumes a resinous consistence, in process of time. This substance has an acrid, bitter, and nauseous taste; its smell is strong, aromatic, and even fetid: it consists of a coloured, resinous matter, soluble in alcohol, and ether, together with a gelatinous mucilage, and an extractive part taken up by water, and a salt, which crystallizes in the aqueous solution by evaporation, but whose nature has not yet been examined. The resin of castoreum appears to be analogous to that of bile. All the substance of this animal product is inclosed in membranous cellules, which proceed from the internal tunic of the bag which contains them. The castoreum has not yet been accurately analyzed; it is only ascertained, that it affords a small quantity of volatile oil, and ammoniacal carbonat by distillation, and that the several matters of which it is composed may be separated by means of ether, alcohol, and water.

It is medicinally used as a powerful antispasmodic in hysterical and hypochondriac affections, and the convulsions which are caused by those affections: it often produces the most speedy and happy effects, but it sometimes happens that it irritates instead of calming, according to the disposition of the nerves and sensible system; it must for this reason be administered at first only in small doses: it has likewise been success-

fully administered in the epilepsy and tetanus. The dose is from a few grains to half a drachm in substance; it enters into the composition of boles, and is often united, almost always advantageously, with opium, and the sedative or narcotic extracts; its spirituous and ethereal tinctures are likewise used, from a few drops to twenty-four or thirty-grains, in proper liquids.

§ II. *Of Musk.*

Musk is a substance, whose strong and permanent smell is universally known; it is contained in a bag placed near the umbilical region of a ruminating quadruped, resembling the antelope, from which it does not differ sufficiently to form a particular genus. This substance resembles castoreum in its chemical properties; it consists of a resin, united to a certain quantity of mucilage, bitter extract, and salt; it is often falsified; its virtues are stronger than those of castoreum; and, on account of its greater activity, it is used only in cases of imminent danger. It is prescribed as a powerful antispasmodic in convulsive disorders, the hydrophobia, &c.; and is likewise considered as a violent aphrodisiac. It must be used with great caution, because it often excites nervous affections, instead of mitigating them.

§ III. *Of Hartshorn.*

Hartshorn is an animal substance which is very frequently used in medicine; it is a bony substance, and does not in any respect differ from other bones; it contains abundance of tasteless jelly, very light and nourishing, which is extracted by boiling the substance, reduced into small pieces, in eight or ten times its weight of water. When distilled in a retort, it affords a reddish and ammoniacal phlegm, called *volatile spirit of hartshorn*; an oil, more or less empyreumatic; and a large quantity of ammoniacal carbonat, contaminated by a small quantity of oil. A prodigious quantity of elastic fluid is disengaged, consisting of a mixture of carbonic acid, azotic gas, and hydrogenous gas, holding charcoal and even volatile oil in solution. This last is gradually precipitated in cooling, and adheres to the sides of the glass jars in which the elastic fluid

is preserved. As the volatile salt is coloured, it is necessary to digest it in a small quantity of alcohol, which takes away the colouring oil. The carbonaceous residue being incinerated, is found to contain a small quantity of carbonat of soda, sulphat of lime, and much calcareous phosphat, mixed with phosphat of soda, which may be decomposed by sulphuric acid, in the manner already described in treating of bones.

The spirit and the salt of hartshorn are used in medicine as good antispasmodics; the first, saturated with the succinic acid, forms the fluid called succinated spirit of hartshorn.

The oil of hartshorn, rectified by a gentle heat, becomes very white, odorous, volatile, and almost as inflammable as ether; it is known by the name of the *animal oil of Dippel*, a German chemist, who first prepared it. A great number of rectifications were formerly made to obtain this oil very white and fluid; but it has since been discovered, that two or three distillations are sufficient, provided care be taken, 1. To introduce the oil into the retort, by means of a long funnel, in order that the neck of this vessel may be very clean, as a single drop of the coloured oil is sufficient to give a tinge to all that comes over. 2. To take only the first most volatile and whitest portions. We are indebted to Model and Baumé for these observations. Rouelle has likewise given a very good process for obtaining this oil: it consists in distilling it with water: and as there is only the most volatile and truly ethereal part contained in the oil of the first distillation, which is capable of rising at the degree of heat of boiling water, this method is attended with a certainty of the most attenuated and penetrating portion coming over alone. The animal oil of Dippel has a lively smell, and a singular degree of lightness and volatility, and exhibits all the properties of vegetable volatile oils, from which it does not appear to differ, but in containing ammoniac, as appears by its converting syrup of violets to a green, according to the observations of Parmentier. This oil is used in drops, in nervous affections, the epilepsy, &c.

§ IV. *Of the White of the Whale.*

The white substance, improperly called *spermaceti*, is an oily, concrete, crystalline, semi-transparent matter, and of a peculiar

smell, which is taken out of the cavity of the cranium of the cachalot; it is purified by liquefaction, and the separation of another fluid and inconcrescible oil, with which it is mixed. This substance exhibits very singular chemical properties; for it resembles fixed oils in some respects, and volatile oils in others.

The white of the whale, heated with the contact of air, takes fire, and burns uniformly without emitting any disagreeable smell. It is therefore made into beautiful candles at Bayonne, at St Jean de Luz, &c. There are several manufactures of these candles in England, and there has been one established at Paris for some years past.

When distilled by a naked fire, it does not afford an acid phlegm like fixed oils, as Thouvenel has observed, but it passes entirely, and almost without alteration, into the receiver, as soon as it begins to boil, and leaves a coaly mark in the retort. By repeating this operation, it loses its solid form, and remains fluid without becoming more volatile.

The white of the whale, exposed to a hot air, becomes yellow and rancid, but less readily than the other concrete fixed oils. The water in which it is boiled affords only a light mucoso-unctuous residue.

The caustic alkali dissolves the white of the whale, and forms a soap which gradually becomes solid, and even friable.

The nitric and muriatic acids have no action on it. The concentrated sulphuric acid dissolves it, and alters its colour. This solution is precipitated by water, like the oil of camphor.

The white of the whale unites with sulphur like the fixed oils.

The fixed and volatile oils dissolve the white of the whale by the assistance of heat; hot alcohol likewise dissolves it, and suffers it to precipitate by cooling. Ether effects this solution in the cold, or by the natural heat of the hand.

Has not the white of the whale the same relation to fixed oils, as camphor to volatile oils? It really differs from wax; it appears to be, with respect to the former of these oils, the same which resin is to the latter.

This substance was formerly much used in medicine, a great number of virtues having been attributed to it; it was more particularly used in catarrhs, ulcers of the lungs, of the reins, &c. It is not at present used, except as a softening remedy, and then in small doses, mixed with mucilages, because it is found to lie heavy on the stomach, occasioning nausea, and even vomiting.

I have found in animal matters, and particularly in the parenchyma of the liver, dried in the air for several years, in the human muscles altered by putrefaction, and in human biliary concretions, a substance which possesses characters very similar to those of the white of the whale. It appears to me that this substance is very abundant in the animal kingdom, and that it is an oil which particularly belongs to this kingdom.

§ V. Of *Ambergrise*.

Ambergrise is a concrete matter, of a soft tenaceous consistency, like wax, of a grey colour, marked with yellow or black spots, and of a strong, sweet smell, when it is heated or rubbed. It exists in irregular masses, which are sometimes round, and consists of layers of different sorts, and either greater or smaller, according as the number united in the mass is greater or less. There have been pieces of it seen, which weighed more than two hundred pounds. This substance appears evidently to have once been in a liquid state, as various extraneous matters are found incorporated with it; such as the neb of the cuttle fish, bones of fishes, and other marine bodies. Ambergrise is found floating on the waters of the ocean near the Molucca Isles, Madagascar, Sumatra, and on the coasts of Coromandel, Brazil, Africa, China, and Japan. Some American fishermen informed Dr. Schwediaur, an English physician, that they had often seen this matter among the excrements of that species of the whale, which Linnæus calls *physeter macrocephalus*, in his intestines, or in a bag situated, as is said, beside them, and probably the cæcum. Naturalists take notice of a good many varieties of ambergrise. Wallerius reckon the six that follow:

Varieties.

1. Grey ambergrise, with yellow spots.
2. Grey ambergrise, with black spots.

These two varieties are the most valuable, and the most in request.

3. White ambergrise, of only one colour.
4. Yellow ambergrise, of no more but one colour.
5. Brown ambergrise of a single colour.
6. Black ambergrise of a single colour.

It is to be observed, that these varieties are owing to a mixture of some extraneous substances.

There is a great disagreement among philosophers concerning the origin of ambergrise. By most of them it has been considered as a bitumen, a sort of petroleum, issuing from the rocks, and condensed by the action of the sun and the water of the sea. Others have imagined it to be made up of the excrements of birds nourished on odoriferous herbs. Others, again, have ascribed its origin to the froth thrown out by sea-calves, the excrements of the crocodile, &c. Pommet and Lemery thought it a mixture of wax and honey, hardened by the action of the sun, and altered by the sea-water. M. Formey, who has adopted this opinion, supports it by an experiment which consists in digesting wax and honey. He asserts, that a product may thus be formed, of an agreeable smell, nearly the same with that of ambergrise. Some English authors have considered ambergrise as an animal juice, deposited in bags situated near the root of the genital organ in the male whale; and others have imagined, that it is formed in the bladder of that cetaceous animal: But the nebs of cuttle-fishes, found in this concrete juice, are sufficient to confute these opinions. Lastly, Dr. Schwediaur, after examining a great many specimens of ambergrise, and receiving accounts concerning it from different navigators, has concluded this substance to be formed in the alimentary canal of the *physoter macrocephalus*,—the species which affords the *spermaceti*, or white of the whale. He considers ambergrise as an excrement of this cetaceous animal, mixed with some parts of its food, 1. Because fishermen find it in these whales: 2. Because it is com-

mon in the latitudes which they inhabit : 3. Because beaks of the cuttle-fish with eight feet, *sepia octopoda*, on which that animal lives, are always found in it : 4. Because he distinguished the black spots mixed through ambergrise to be the nebs of this polypous animal. 5. Lastly, Because the excrements of several quadrupeds, as cows, hogs, &c. exhale an odour similar to that of ambergrise, when kept for any length of time. His researches have raised this opinion of the Japanese, and of Kempfer, to an high degree of probability ; for which reason, we now rank this matter among the products of the animal kingdom.

Yet this substance, which has been analysed by Geoffroy, Neuman, Grim, and Brow, afforded to those chemists the same principles with bitumens ; that is to say, an acid spirit, a concrete acid salt, some oil, and a carbonaceous residue. But Dr. Schwediaur observes, with great propriety, that the calculi of animals afford an acid, and that the existence of this salt is in favour of his opinion, for fat contains a great deal of it.

Ambergrise is stomachic, cordial, antispasmodic. It is used in doses of several grains, in certain drinks, or mixed with other substances, in pills. The odorous principle of this medicine is often too active, too penetrating, and liable to do harm. It is well known, that many persons cannot bear the smell of it without feeling their nerves very disagreeably affected : it should therefore be administered very cautiously. It has been also considered as a powerful aphrodisiac. Some modern physicians, however, think that ambergrise may be prescribed in very copious doses, without producing any very powerful effects.

Ambergrise is chiefly used as an article of perfume for the toilet : it is usually mixed with musk, the smell of which it weakens so as to render it much more agreeable. Yet every person is not fond even of this mixture.

As ambergrise is very dear, it is counterfeited and mixed with different substances. When genuine, it displays the following properties : It is scaly, insipid, and sweet-smelling ; it melts without rising in bubbles or froth, when exposed, in a silver-spoon, to the flame of a taper ; it swims on water, and

does not stick to hot iron. Ambergrise, which does not exhibit these properties, is to be considered as impure.

§ VI. *Of the Eggs of Birds.*

The eggs of birds, and particularly those of poultry, are composed, 1. Of a bony shell, which contains a jelly, and calcareous phosphat, as Berniard has proved. 2. Of a membranous pellicle, placed beneath the shell, and which appears to be an expansion of fibrous matter. 3. Of a whitish fluid substance. 4. Of a yellow substance contained and suspended in the middle of white; the germ is supported on this last substance.

White of egg is absolutely of the same nature as the serum of blood; it is viscid and adhesive; it converts the syrup of violets to a green, and contains carbonat of soda in a disengaged state: Exposed to a gentle heat, it coagulates into a white opaque mass, which emits the fetid smell of sulphurated or *hepatic* hydrogen gas. The white of egg coagulated and dried in a water-bath, affords an insipid phlegm, which putrefies, becomes dry, and of a reddish transparency resembling horn; by distillation in a retort, it affords ammoniacal carbonat, and empyreumatic oil; its coal contains soda, and a small quantity of calcareous phosphat. Deyeux has likewise obtained a small quantity of sulphur by sublimation.

White of egg exposed to the air in fine stria, dries without putrefying, and forms a kind of transparent varnish. It is dissolved in water in all proportions; acids coagulate it, and if the coagulum diluted with water be filtered, the fluid which passes through affords by evaporation a neutral salt, consisting of the acid which has been used combined with the soda, contained in the white of the egg; alcohol likewise coagulates this fluid; lime water precipitates calcareous phosphat, and the mercurial nitrat precipitates phosphat of mercury, which by drying assumes a rose colour.

The yellow, or yolk of the egg, is for the most part composed of an albuminous substance, which is mixed with a certain quantity of a mild oil, so that the mixture dissolves in water, and forms a kind of animal emulsion, called *hen's milk*; if it be exposed to heat, it becomes less solid than the

white; when dried, it undergoes a kind of softening, that arises from the disengagement of its oil, which exudes from its surface; in this state, the oil may be obtained by pressure, and is found to be mild and fat, and of a taste and smell slightly empyreumatic. The yolk of egg, after the oil has been thus extracted, affords the same products by distillation, as all other animal matters. Acids and alcohol coagulate it; the mild oil it contains exhibits a striking analogy between the eggs of animals and the seeds of vegetables, since these last likewise contain an oil which is in the same manner united with mucilage, and reduced to the emulsive state.

Eggs are of great use as food; the different parts are used in pharmacy and in medicine; the calcined shell is used as an absorbent; the oil of egg is softening, and is externally used in burns, chaps, &c.; yolk of egg renders oil soluble in water, and forms lochcs; it is triturated with resins, camphor, &c. The white of egg is successfully used in pharmacy and confectionary, to clarify the juices of plants, wheys, syrups, and other fluids; it is likewise applied on paintings, which it preserves, by forming a transparent varnish on their surface.

§ VII. *Concerning Fish Glue.*

Icthyocolla, or fish glue, is a substance partly gelatinous, and partly lymphatic, which is prepared by rolling up the membranes that form the air bladder of the sturgeon, and several other fishes, and is dried in the air, after it has been twisted into the form of a short cord as we receive it. This substance affords a viscid jelly by ebullition in water; by maceration for a certain time in that fluid, it may be unwrapped and extended into a kind of membrane. It is never brittle like glues properly so called, but bends by virtue of its fibrous and elastic texture. A kind of glue is likewise prepared by boiling the skin of the stomach and intestines of fishes, but it has not the same properties as isinglass or fish glue. Icthyocolla affords all the products of other animal substances; it may be used in medicine as an emollient in disorders of the throat, intestines, &c.; but many other vegetable substances, which possess the same virtue, are commonly preferred. It is used in the arts to

clarify liquors, wine, coffee, &c.; it attracts and precipitates all the foreign substances which affect their transparency.

§ VIII. *Concerning the Tortoise, the Frog, and the Viper.*

The tortoise, the frog, the lizard, and the viper, are used in medicine, decoctions of soups being made with their flesh and bones, to which peculiar virtues are attributed. It should seem, in fact, that the animals, whose parts in general have a stronger smell, and appear to contain more saline matter, since they afford a large quantity of ammoniac, when distilled by a gentle heat, after trituration with potash; it should seem, I say, that these animals must possess stronger and more numerous virtues. Many physicians, however, call their virtues in question, and class them with other animals. Notwithstanding this opinion, it is still customary to administer decoctions or soups of tortoise and frogs in disorders attended with languor, consumptions without apparent cause, or any state of weakness which succeeds acute fevers; and it is often found that good effects follow. These decoctions appear to be more nourishing, lighter, and at the same time possessed of a certain activity, sufficiently indicated by their strong smell and peculiar taste. Green lizards have been greatly recommended for some years past, in disorders of the skin, cancers, &c. But these virtues may be doubted.

Vipers are considered as the most active; the ancients spoke highly of their virtues in disorders of the skin, in those of the breast, and in chronical disorders, wherein the lymph is vitiated. We think that their decoctions must throw off the vicious matter through the pores of the skin, by virtue of their exalted aroma; their powder and their volatile salt are far from possessing the same virtues; to produce their full effects the whole animals should be administered as articles of food in the above diseases.

The chemical analysis of these animals by Thouvenel, afforded a jelly, more or less light, consistent, or viscid, an acrid bitter and deliquescent extract, an albuminous concrescible substance, an ammoniacal salt, and an oily substance of a peculiar taste and smell, sometimes soluble in alcohol, &c.

§ IX. *Concerning Cantharides.*

Cantharides, a remedy of so great importance by its corrosive and epipastic quality, consist, according to Thouvenel, 1. Of a parenchyma, whose nature he has not determined, and which amounts to half the weight of these dried insects. 2. Of three drachms in the ounce, of a reddish yellow, very bitter extractive substance, which affords an acid by distillation. 3. Of twelve grains per ounce of a yellow and wax-like matter, which produces the golden yellow colour of the cantharides. 4. Of sixty grains of a green oily wax-like substance, of an acrid taste, in which the odorous principle of cantharides chiefly resides. This substance, when distilled, affords a very penetrating acid, and a concrete oil, resembling wax; water dissolves the extract, the yellow oil, and even a small quantity of the green oil; but ether attacks only this last, and may be successfully employed to separate it from the others. The virtue of the cantharides depends on this kind of green wax. To obtain the latter, at the same time with the extractive substance, and to form in general a tincture well charged with these insects, a mixture of equal parts of alcohol and water must be used, this mixed tincture being distilled affords an alcohol with a slight odour of cantharides, and the different substances it held in solution are separated, one after the other, in proportion as the evaporation goes forward.

§ X. *Concerning Ants and the Formic Acid.*

The acid of ants was observed by Tragus, Bauhin, and several other botanists, who observed the flower of chicory to become very red in ant heaps. Samuel Fisher, Etmuller, and Hoffman, have successively made experiments on this acid. Margraaff carefully examined it, and found that ants contain a peculiar acid, fixed oil, and an extract. Ardwisson and Oerne have made the most complete series of experiments on this acid.

The acid of ants is obtained more especially from the red ant, *formica rufa*, either by distilling them in a retort, or by washing them in boiling water. This acid, when rectified, and rather concentrated, has a penetrating smell, and is corrosive;

its taste is agreeable when greatly diluted with water, and it has thence been proposed to be used instead of vinegar; it quickly reddens all blue vegetable colours, is decomposed by fire, which converts one of its principles into the carbonic acid, and by the sulphuric and nitric acids which disengage the same carbonic acid: it deprives the oxygenated muriatic acid of its oxygen; it is stronger than the sulphuric, boracic, carbonic, acetous, or nitrous acids. It forms a kind of ether with alcohol; the neutral salts it constitutes with alkaline bases have been examined by Ardvisson and Oerne. The formiate of potash has been prepared by Thouvenel, by spreading linen impregnated with potash on ant hills uncovered; the ants running over the cloth emitted their acids, and odorant principle of the same nature, which they exhaled in so great an abundance, as to saturate the fixed alkali spread on the cloth. The lixivium of these linens afforded, by evaporation, a neutral salt crystallized in flat parallelograms, and prismatic columns which were not deliquescent.

Lime with this acid forms a crystallizable and soluble salt; in a word, the modern chemists consider the acid of ants as a peculiar acid, *sui generis*. Its attractions have been disposed in the following manner by Messrs. Ardvisson and Oerne: barytes, potash, soda, lime, magnesia, ammoniac, zinc, manganese, iron, lead, tin, cobalt, copper, nickel, bismuth, silver alumine.

Alcohol, digested on ants, extracts a small quantity of volatile oil, which, with this fluid, forms the *spirit of magnanimity* of Hoffman. If these insects be boiled in water, and afterwards pressed, a fixed oil is afforded, amounting to about thirteen drachms in the pound; this oil is of a greenish yellow, congeals at a much warmer temperature than oil of olives, and greatly resembles wax. The water of the decoction affords a reddish brown extract by evaporation, which has a fetid, acidulous, and caseous smell, with a bitter, nauseous, and acid taste. This extract is separated into two substances by the successive application of water and alcohol: the parenchyma of ants deprived of these different substances amounts to three ounces two drachms in the pound.

§ XI. Concerning Wood-Lice.

The species *millipedes*, *acelli*, *porcelli*, *onisci*, &c. of wood-lice, presented certain peculiar circumstances in their analysis made by Thouvenel. By distillation on the water-bath without addition, they afford an insipid and alkaline phlegm, sometimes effervescing with acids, and converting the syrup of violets to a green: in this operation they lost five-eighths of their weight. By treatment with water and alcohol, they afterwards afforded two drachms of soluble matter, in the ounce; of which more than two-thirds were extractive matter, and the residue an oily or wax-like substance. These two matters were easily separated by ether, which dissolves the latter without touching the extract; they differ from those of cantharides and ants, in affording more ammoniacal carbonat, and no acid in their distillation. Thouvenel observes, on this subject, that among insects the wood-lice appear to have the same relation to cantharides and ants, which reptiles have with respect to quadrupeds.

The neutral salts contained in these insects are very small in quantity, and very difficult to be extracted. Thouvenel affirms, that the wood-lice and earth-worms, *lumbrici*, constantly afforded him calcareous muriat, and muriat of potash; while in ants, and cantharides, these two bases, the first of which always appeared to him the most abundant, are united with an acid, which has the character of the phosphoric acid. It is necessary to be observed here, that this chemist in his Dissertation, has not described either the methods of extracting these salts, nor the processes he made use of to ascertain their nature.

Cantharides and wood-lice are alone used in medicine; the latter appear to act as stimulants, and slight diuretics, and for this purpose they ought to be administered according to the experiments of Thouvenel, in a much more considerable dose than is usually prescribed. The expressed fluid of forty or fifty living wood-lice given in a mild drink, or mixed with the juice of certain aperient plants, may be successfully prescribed in the jaundice, ferous disorders, à *serosa colluvie*, coagulations of the milk, &c. As to the cantharides, it is one of the most powerful medicines we are in possession of. Thou-

venel tried on himself the effect of the green waxy matter, in which the virtue of these insects seems to reside ; when applied on the skin in the quantity of nine grains, it raised a blister full of serous matter, in the same manner as the powder of cantharides ; but the most valuable observations resulting from his experiments on this powerful remedy, are that the spirituous tincture of cantharides may be used with the greatest success externally, in a dose of two drachms to two ounces and an half, in rheumatic and sciatic pains, and in the wandering gout ; it heats the skin, accelerates the circulation, and excites evacuation by sweat, urine, and stool, according to the parts on which it is applied ; but young practitioners ought to be advised that the internal use of this medicine should be very moderate, as it has been known to produce flushings on the skin, inflammations, sweating of blood, and pains in the loins and bladder, dysenteries, &c.

§ XII. *Concerning Honey and Wax.*

Honey and wax, prepared by bees, seem to belong to the vegetable kingdom, since these insects collect the first in the nectaria of the flowers, and the second in the antheræ of their stamina ; nevertheless they have passed a peculiar elaboration, and besides, as they are obtained in consequence of the labour of bees, their properties ought to be examined in the history of insects.

Honey is a substance perfectly resembling saccharine juices, which we have treated of under vegetables. It has a white or yellowish colour, a soft and grained consistence, a saccharine and aromatic smell ; by means of alcohol, and even by water, with peculiar management, a true sugar is obtained ; by distillation it affords an acid phlegm and an oil, and its coal is light and spongy like that of the mucilages of plants. Nitric acid extracts the oxalic acid, which is entirely similar to that of sugar ; it is very soluble in water, with which it forms a syrup, and like sugar, passes to the vinous fermentation ; it is an excellent food, and a softening and slightly aperient medicine ; it is given dissolved in water, and mixed with vinegar, under the name of oximel. It is often combined with different acrid plants, as in the oxymel of squills, of colchicus ; it is the

vehicle in many medicines which bear its name, as the honey of roses, honey of water-lily, mercurial honey, &c.

Wax is a concrete oily substance, similar to the solid fixed oils, such as the butter of cocoa, and still more resembling vegetable wax. Though it cannot be doubted that this substance is extracted from the stamina of flowers, it is nevertheless certain, that it receives a peculiar elaboration in the body of the animal; since, according to the trials of Reaumur, a flexible wax cannot be made with the powder of the antheræ. Wax which composes the honey-combs is yellow, and of an insipid taste; it is whitened by exposure to the action of dew, and of the air, after it has been reduced into thin pieces. The oxygenated muriatic acid whitens it very quickly; by a gentle heat it softens, melts, and forms a transparent oily fluid, which becomes solid and opaque by cooling; when strongly heated with the contact of air, it takes fire as soon as it is volatilized; and this is the effect produced by the wick in candles. When distilled in a retort it affords sebatic acid, and an oil at first fluid, which afterwards fixes in the receiver, and has the consistence of butter; it leaves only a very small quantity of coal difficult to incinerate. Butter of wax being rectified a number of times, becomes fluid and volatile.

White wax does not alter by exposure to the air, except that it becomes coloured at the end of a certain time. It dissolves in oils to which it gives consistence; when melted in these fluids in a mild heat, it forms medicines, known by the name of *cerates*; alcohol does not act on wax; acids blacken it, alkalis combine with it, and reduce it to a saponaceous state.

Wax is used in a great number of arts; in pharmacy it is used in the preparations of pomatums, unguents, and plasters.

§ XIII. Concerning Silk Worms, the Bombic Acid, and Silk.

Silk worms contain, especially when in the state of chrysalis, an acid liquor in the reservoir placed near the anus. Chauffier, of the Academy of Dijon, obtained this acid by expressing the juice of the chrysalides in a cloth, and precipitating the mucilage by alcohol, and likewise by infusing the chrysalides in that liquor. Alcohol in separating it, carries the acid along with it through the filter, and there remains on the paper an orange-

coloured fat oil, a gummy matter, and a small quantity of gluten. To obtain the bombic acid pure, the alcohol must be distilled, by which it is volatilized, and the acid remains pure in the retort. This acid is very penetrating, of a yellow amber colour, but its nature and combinations are not yet known.

Many other insects likewise contain acids; the large caterpillar of the willow emits a liquor considerably acid, according to the remark of Bonnet. I have often observed the buprestes and staphylini give a red colour to the blue paper with which boxes were lined, wherein they were put. Chauffier has likewise obtained an acid from the grafshopper, the red bug, the lampyris, or shining worm.

Silk, which seems to be nothing but a kind of gummy matter dried, differs nevertheless from vegetable substances, 1. By the ammoniac it affords in distillation. 2. By the azotic gas obtained from it, by means of the nitric acid. 3. By the peculiar oil which this acid separates in proportion as it converts it into oxalic acid, as Berthollet has shown. It seems to be a compound of vegetable mucilage with a peculiar animal oil, which gives it flexibility, ductility, and elasticity.

§ XIV. Concerning Resin-Lac.

The improper name of gum-lac is given to a resinous substance of a deep red, which is deposited on the branches of trees, by a kind of ant peculiar to the East Indies. This substance appeared to Geoffroy to be a kind of nidus, in which the ants deposit their eggs. In fact, if stick-lac be broken, it is observed to be full of small cavities, or regular cellules, in which small oblong bodies are placed, which Geoffroy has considered as the embryos of ants. He thinks that the lac owes its colour to this animal substance; he regards the lac as a true wax, though its dryness, the aromatic odour it exhales in burning, and its solubility in alcohol, seem to indicate a resemblance between it and resins; by distillation it affords a kind of butter, according to the same author. It is now ascertained, that lac is formed by a species of *evacus*, who deposits it on the branches of a species of *croton*, which is on that account named *croton lacciferum*. It is distinguished in commerce into stick-lac, seed-lac, and shell-lac. We must likewise observe, that

many other colouring substances, particularly red animal or vegetable fecula, when prepared in a particular manner for dyeing, are called *lacs*. Refin-lac is used in the Levant to dye cloths and skins. It is the basis of sealing wax; a tincture is made with it, together with the spirit of cochlearia; it enters into the troches of amber, dentrifice powders, and opiates, odorous pastills, &c.

§ XV. Concerning *Kermes*.

Kermes, or chermes, *coccus infectorius*, was considered by the first naturalists as a tubercle and excrescent of plants. The more accurate observations of subsequent times have shown, that it is the female of an insect arranged among hemiptera by Geoffroy; this female fixes itself among the holm-oak, where, after having been fecundated, it extends itself, dies, and soon loses the form of an insect; it has the appearance of a brown cap, under which are enclosed a very great number of eggs.

This cap was formerly used in dyeing, but has been neglected since the discovery of cochineal. Kermes exhibits the same chemical properties as this last substance; it enters into the syrop of coral, of codex, and into the confectio alkermes.

§ XVI. Concerning *Cochineal*.

Cochineal, like kermes, was long considered as a vegetable grain. Father Plumier is among the first who detected this error; it is, in fact, the female of an hemipterus insect, which differs from the kermes in the circumstance that it preserves its form, though fixed on the plants. The cochineal used in dyeing, grows on the opuntra, or Indian fig-tree; it is collected in great quantities in South America. Geoffroy who analysed it, found it to contain the same principles with kermes; he obtained ammoniac from it. The form of this insect may be seen by macerating it in water. Cochineal is used to make carmine, and in dyeing it produces either a crimson or scarlet colour, according to the manner in which it is used. As it is an extractive colouring matter, it cannot be applied in substances intended to be dyed, but by the help of a corrosive. It readily adheres to wool, and tinges it of a scarlet colour, by means of the solution of tin in muriatic acid, which

decomposes the colouring extract, and singularly enlivens the tinge. The method of giving this beautiful colour to silk was not known before the time of Macquer; this celebrated chemist discovered that silk may be dyed, if previously impregnated with the solution of tin, before it is plunged in the bath of cochineal, instead of mixing the solution in the bath, as is done with wool.

§. XVII. Concerning Crab's Stones.

The stony concretions, falsely called *crab's eyes*, *lapides cancerorum*, are found in the number of two in the internal and inferior parts of the stomach of these crustaceous insects; they are round, convex on one side, concave on the other, and placed in the animal between the two membranes of the ventricle. As they are not found, but at the time in which the crabs change their covering and their stomach; and as they disappear gradually in proportion as the new covering becomes hard, it is thought, with great probability, that they serve to reproduce the calcareous substance, which constitutes the basis of their shells.

These stones have no taste; they contain a small quantity of gelatinous matter; they are prepared by repeated washing and grinding on a stone, with a small quantity of water, to reduce them into a soft paste, which is moulded into lozenges, and dried; the water carrying off the animal jelly contained in these stones; the residue is mere earthy matter. When prepared in this manner, they make a strong effervescence with all acids, and are absolutely of the same nature as chalk; they have, therefore, no other virtue than that of absorbing acidities in the first passages; and the opinions, in consequence of which animal substances in general have been placed in the rank of aperient, diuretic, and even cordial remedies, are very far from being well founded.

§ XVIII. Of Coral.

The same observation likewise applies to coral, which is a calcareous white earth, or rose-coloured ramification, forming the basis of the habitation of the sea polypi. Preparations of these are made in the same manner as from crab's eyes, and it is of the same calcareous nature as that substance; it enters in-

to the confectio alkermes, pulvis gutteri, and amber troches. Numberless virtues have been attributed to it, but it possesses no other than that of a mere absorbent, unless it be combined with acids; this, as well as crabs eyes, is often in the state of a neutral salt, combined with vinegar or lemon juice, as an aperient, diuretic, &c.

§. XIX. Concerning True Coralline.

The coralline, called *sea-moss*, is, as we have observed, a peculiar habitation of polypi. It affords the same principles in the retort as animal substances, and has a salt, bitter, and disagreeable taste; it is successfully used as a vermifuge, with which intention it is prescribed in powder, in the dose of twenty-four grains for infants, to that of two drachms or more for adults. It is made into an anthelminthic syrup, and enters into vermifuge powders. This common coralline must not be confounded with the substance at present called *coralline of Corsica*, or *helminto-corton*: this last is a vegetable, a kind of fucus, which has the property of forming a jelly with hot water.

CHAPTER XV.

RESULT OF THE ANALYSIS OF ANIMAL SUBSTANCES; COMPARISON OF THESE SUBSTANCES WITH VEGETABLE MATTERS.

IN the fourteen preceding chapters, we have exhibited the actual state of our present knowledge concerning the nature of animal substances. Those who have cultivated chemistry for the last twenty years, will easily perceive how much that science has gained in this respect, and the singular progress it has made in this department. Though a much greater number of discoveries, beyond what is at present known, remains to be made, to complete the history of animal matters, yet those we at present possess are of much greater value than what we formerly possessed. The course necessary to be held in this great work is at least discovered, and we need be no longer apprehensive of consuming our time in false pursuits; it is

clearly seen, how much the philosophy of animal substances and the science of medicine may expect from chemistry, when these two sciences are connected together. If this assertion required any additional proofs to what we have already given in detail in the foregoing chapters, the short resumption we shall exhibit in this place would be sufficient to answer their purpose.

Those substances which have been called the immediate principles of organic bodies, that is to say, the matters which are separated immediately, and without alteration from organized substances, greatly resemble each other; whether they be extracted from animals or vegetables. In fact, we find in both, extracts, the saccharine principle, insipid mucilages, acid and alkaline salts, fixed and volatile oils, resins, glutinous matter, an aromatic principle, and colouring substances. But notwithstanding this analogy, which has long been perceived, there still remain among the immediate principles of the two kingdoms, very remarkable differences, the examination of which deserves all the attention of philosophers.

1. The extract and saccharine matters are very far from being as abundant in the animal as in the vegetable kingdom.

2. The animal mucilages are not entirely of the same nature; they are softer, not so easily dried, and are disposed to attract the humidity of the air; they take the form of a jelly in cooling; their taste is stronger, they become sour, and more especially they putrefy much more rapidly.

3. The fixed oils in the animal kingdom likewise differ from those of vegetables. They are found collected in greater masses, and in particular cells; they are always more or less concrete; and in many instances they are even capable of becoming dry, and assuming the crystalline form.

4. Volatile oils and resins are in general rarer, and much less abundant in animals than in vegetables. It seems as if Nature had been careful to remove from the sensible and irritable organs of animals, such acrid substances which would have continually stimulated the fibres; and that she has even confined them to the external parts, and the vicinity of the tunics in vegetables.

5. The albuminous matter, which is concrescible by heat,

though it exists in the juices of plants, is much less abundant in them than in animals; in all the parts of which it is found, and often in very considerable quantities.

6. The fibrous substance, though analogous to the gluten of flour, has, nevertheless, more tenacity and elasticity in animals: besides which, they contain it in so large a proportion, that even if there were no difference between animals and vegetables, this alone would deserve to employ the whole attention and research of philosophers. All the muscles, or all the organs of motion, are composed of this; and as animals possess a mobility which is not seen in vegetables, the parts necessary to move them ought to differ essentially from that which constitutes the motionless bodies of plants.

7. But it is more especially in the nature of their saline matters, that animals differ from vegetables. Besides the salts and saline radicals analogous to those of the vegetable kingdom, which are found in animals, such as lime, soda, the muriatic, oxalic, malic, benzoic, sebacic, and phosphoric acids, there have been extracted from them the lactic, saccholactic, lithic, formic, and bomic acids, whose nature is not known, but which do not appear to exist in vegetables. We likewise find in animals, much more abundantly than in vegetables, the principles necessary for the formation of ammoniac and the prussic acid; and it is more particularly by this character that animal matter differs from vegetable. The principles necessary to the formation of ammoniac and the prussic acid, viz. azot, hydrogen and carbon, are even so abundant in animal substances, that these two compounds are very often found ready formed in them, more especially some time after the death of animals. I have found Prussian blue in putrid animal substances: I have even seen in a sick person, whose blood was greatly altered, this fluid assume the brightest blue colour by exposure to air. But it must not be overlooked, that vegetables likewise contain the principles of prussic acid, though much less abundantly than animal substances. With regard to ammoniac, its readier and much more frequent formation in animal than in vegetable matters, shows that its principles are much more abundant; and indeed Berthollet has proved, that these matters afford a very great quantity of azotic gas, by

means of the nitric acid. I have proved after him, that, when this gas is extracted, these substances no longer afford ammoniac; it is, therefore, to the presence of this principle that they are indebted for the property of affording, in these artificial or spontaneous analyses, a great quantity of this alkaline salt.

If we proceed to inquire what are the more simple primary principles of which these immediate principles are compounded, we shall find, that the only component parts of animal matters are, like those of vegetables, hydrogen, carbon, azot, and oxygen. These substances, hitherto indecomposable, these kinds of elements, appear to constitute, by their combinations, oils, acids, mucilages, the fibrous matter, &c. These various immediate principles do not differ from each other, but in the number and respective proportion of the primitive substances which compose them. But as animal matters, though formed in general of the same principles as vegetable substances, do nevertheless possess properties really different; the productive cause of these differences appears to exist only in the various proportion of these principles. Thus the quantity of azot, which is much more considerable in animal matters than in vegetable substances, already explains a great part of these differences: it shows why animal substances affords much ammoniac by the action of fire, why they putrify so readily, why they are necessary to the production of the acid of nitre, &c. Nothing more is required to be done than to determine what kind of change it is that vegetable matters undergo, in passing into the bodies of animals; for it is certain that vegetable matters alone affords nourishment to animals, and are converted into their proper substance. We shall here take notice, that several immediate principles of vegetables pass without alteration, and preserve their own proper nature in the bodies of animals, or at least are very little changed: such in particular are several salts, the fixed oils, &c. But the different kinds of mucilages, the gluten, and the colouring matters, manifestly change their nature; the gummy matter becomes gelatinous; the gluten passes to the state of fibrous matter; the base of azotic gas, or azot, is fixed, and combines in great quantities in these substances, and seems, by its mere fixation, to change vegetable into animal matter. It is to this change,

and the formation of the various animal substances, that physiologists ought to direct their attention more particularly: in a word, it is the problem of animalization which remains to be resolved. Analysis has already afforded some useful data for this solution; but many more remain to be investigated: and it is chemistry alone, which, by its accurate processes, can encourage us to hope for the union of a number sufficiently considerable to arrive at this result, so useful to the philosophy of animal bodies.

CHAPTER XVI.

CONCERNING THE PUTREFACTION OF ANIMAL SUBSTANCES.

THOUGH vegetable substances are susceptible of decomposition, and entire destruction, by the putrid fermentation, they are nevertheless in general far from being as capable of entering into this state of intestine motion as animal matters; the putrefaction of these last is much more rapid, and its phenomena are different: all the fluids and soft parts of animals are alike capable of undergoing this process, while many vegetable matters seem exempted from it, or at least are not changed by it but slowly, and with great difficulty.

The putrefaction of animals, which we cannot but consider, with Boerhaave, as a true fermentation, is one of the most important phenomena, and at the same time the most difficult to be known; all the labours of the philosophical world, since the time of Bacon of Verulam, who was well aware of the importance of inquiries into this subject, have served only to clear up a few circumstances, and to exhibit the general phenomena of putrefying substances. Beccher, Hales, Stahl, Pringle, Macbride, Geber, Baumé, Madam Darconville, and the authors of the *Dissertations on Antiseptics*, who were crowned in 1767 by the Academy of Dijon, have observed, and carefully described the facts which accompany the putrid change in bodies: but we shall see, in the following pages, that a great number of experiments remains to be made, before we can

esteem ourselves acquainted with the whole of the phenomena of this natural operation.

Every fluid or soft substance, extracted from an animal body, when exposed to a moderate temperature, of sixty-five degrees or more, passes with more or less rapidity through the following changes. Its colour becomes paler, and its consistence diminishes; if it be a solid part, such as flesh, it softens, and a serous matter sweats out, whose colour quickly changes; its texture becomes relaxed, and its organization destroyed; its smell becomes faint, and disagreeable; the substance gradually sinks down, and is diminished in bulk; its smell becomes stronger and ammoniacal. If the subject be contained in a close vessel, the progress of putrefaction, at this stage, seems to slacken; no other smell but that of a pungent alkali is perceived; the matter effervesces with acids, and converts syrup of violets to a green. But if the communication with the air be admitted, the urinous exhalation is dissipated, and a peculiar putrid smell is spread around with a kind of impetuosity; a smell of the most insupportable kind, which lasts a long time, and pervades every place, affecting the bodies of living animals, after the manner of a ferment, capable of altering the fluids: this smell is corrected, and as it were confined by ammoniac. When the latter is volatilized, the putrefactive process becomes active a second time, and the substance suddenly swells up, becomes filled with bubbles of air, and soon after subsides again. Its colour changes, the fibrous texture of the flesh being then scarcely distinguishable; and the whole is changed into a soft, brown, or greenish matter, of the consistence of a poultice, whose smell is faint, nauseous, and very active on the bodies of animals. The odorant principle gradually loses its force; the fluid portion of the flesh assumes a kind of consistence, its colour becomes deeper, and it is finally reduced into a friable matter, rather deliquescent, which being rubbed between the fingers, breaks into a coarse powder, like earth. This is the last state observed in the putrefaction of animal substances; they do not arrive at this term but at the end of a considerable time. Eighteen months, two, and even three years, are scarcely sufficient for the destruction of the whole body of animals exposed to the air; and the time ne-

cessary for the total destruction of bodies buried in the earth has not yet been estimated. Not to mention bodies which in certain soils are dried, and remain unchangeable; many facts prove, that human bodies, buried in great numbers in a moist soil, are not destroyed even at the end of thirty years.

From this outline it follows, 1. That the conditions proper to develop and maintain the putrefaction of animal substances, are the contact of air, heat, moisture, and repose. 2. That ammoniac is one of the products of putrefaction, formed during that process, since it did not exist as such in the animal substances before the commencement of that intestine motion. 3. That putrefaction, effected by the intestine motion, proper to organized matters, may be compared to the action of fire, as Goddard has remarked, and may be considered as spontaneous decomposition, as Baumé thinks, from which it differs only in its slowness. 4. That in this natural operation, the proximate principles of animals re-act on each other, by the assistance of water and of heat, by means of which the motion commenced; that the volatile matters thus formed, become gradually dissipated in the order of their volatility, and that nothing remains after the putrefaction, but an insipid, and as it were earthy substance. 5, and lastly, That the putrid exhalation, which is so well distinguished by the nerves of smell, and whose action is so powerful on the animal economy, may be considered as one of the principal products of putrefaction, as it is peculiar to this operation, and is not observed in any other natural phenomena; and because it appears capable of developing the putrefactive motion in all the animal substances which are exposed to its action. As to the nature of this fugacious odorant substance, we must observe, that it is more particularly with respect to this that inquiries are very little advanced, though they highly deserve to be followed. We only know, that it is extremely volatile, attenuated, and penetrating; that pure air, water in large quantities, and acid gases, are capable of moderating its effects. Though it ought not to be confounded with the carbonic acid gas, which is disengaged in large quantities from putrefying bodies, and to whose disengagement Macbride entirely attributed the cause of this natural phenomenon; and though we are by no means warranted in comparing it, either

to the hydrogen gas disengaged from putrescent bodies, nor with the luminous matter, which shines at the surface of putrid animal fibres, converting them into a kind of phosphorus; yet it must be allowed, that these substances have very evident relations with each other, since it always accompanies them, is equally volatile and attenuating, and acts with equal energy on the organs of animals. Perhaps this substance may be a part of the animal matters reduced into vapour.

Four degrees or stages of the putrid fermentation of animal substances may be distinguished, according to Boissieu.

The first, which this physician calls a *tendency to putrefaction*, consists in an alteration, not considerable, which appears by a faint or slight smell, and a softening of the substance.

The second degree, or *commencement of putrefaction*, is sometimes indicated by marks of acidity: the substances which undergo this, lose weight, become fetid and soft, and a serous matter exudes, if they be in close vessels; or they become dry, and of a dark colour, if exposed to the air.

In the third degree, or *advanced stage of putrefaction*, the putrescent matters emit an ammoniacal smell, mixed with a putrid and nauseous smell; they fall into dissolution, their colour changes more and more, and they lose at the same time both weight and bulk.

Lastly, The fourth degree, or that of *complete putrefaction*, is known by the ammoniac being entirely and completely dissipated; the fetid smell loses its force, the volume and weight of the putrefied substance are considerably diminished, a gelatinous mucus is separated, they dry by degrees, and are at length reduced to a friable and earthy matter.

Such are the general phenomena observed in the putrefaction of animal substances, but they are far from being the same in all matters which putrefy. There is a great difference between the putrefaction of the parts of living animals, and that of their dead organs. The motion which exists in the former, singularly modifies the phenomena of this alteration; and physicians have frequent opportunities of observing the difference between these two states, with respect to putrefaction. Besides this, every humour, and every solid part, separated from a dead animal, has likewise its peculiar way of

putrefying. The muscular, membranous, or parenchymatous texture of the organs; the oily, mucilaginous, or lymphatic nature of the humours, their consistence, their state with respect to that of the animal which afforded them, greatly influence the putrefactive motion, and modify it in a thousand manners, perhaps impossible to be estimated. And how greatly will the difficulty of the subject be increased, if we add to this enumeration, the state of the air, its temperature, elasticity, weight, dryness, or moisture; the exposition of the putrefying substance in various places, and even the form of the vessels which contain it; all these circumstances being capable of varying the phenomena? It must therefore be allowed, that the history of animal putrefaction is scarce begun, and that it demands an immense series of inquiries and experiments.

The phenomena hitherto observed show, that water is the cause of putrefaction; it is most probable that this fluid is decomposed, that its oxygen seizes the azot of the animal substances, and contributes to the formation of the nitric acid, so frequently found in animal matters; and that its hydrogen, united to a portion of the same azot, which abounds in these substances, produces the ammoniac that flies off. The oily principle is preserved for the longest time; the calcareous phosphat, and the phosphat of soda, united to a portion of the carbonaceous principle, and perhaps with a small quantity of fat matter, seem to constitute the apparently earthy residue of putrefied animal matters.

Thus far we have only described the phenomena which take place when animal matters putrefy, and are decomposed in the air: but as the result of this decomposition in different mediums throws a great light on the knowledge of the revolutions of the globe, let us consider for an instant what happens to these matters, plunged in the water, or buried in the earth.

The changes hitherto described, do not take place perfectly in the water. The bodies of animals plunged into this liquid first swell up; elastic fluids are disengaged; the water dissolves a great part of their principles, decomposes another part, and disperses the different principles of these bodies among the great masses that constitute rivers and streams;

whence several nations expose dead bodies in rivers, and commit their destruction to the water.

Other phenomena take place when the bodies of animals are buried beneath the ground. Observations, most of which are the consequence of accidental circumstances, have shown that their destruction varies according to the nature of the ground. Sometimes we find bodies entirely destroyed after a short interval, and sometimes they are found well preserved even after a very long time. It is easy to conceive, that if the earth is very porous and very moveable, if the animal matter be buried at a small depth, the air, and especially the water, which have an easy access to it, will facilitate its decomposition; but that in opposite circumstances it must be much slower. For example, dry earth absorbs the water of bodies, dries them, and converts them into mummy: such is the effect of a sandy soil, in which the bodies receive the impression of a burning sun, and acquire a degree of hardness which defends them from destruction for ages. On the contrary, argillaceous earth retains water, and permits the destruction of bodies. In the cases in which it takes place more or less slowly, the fluids and the solids finish, by being reduced almost entirely into azotic gas, carbonic acid gas, hydrogen gas, and ammoniacal gas. All these elastic fluids being filtered through the earth, are stopped and partly fixed, and render the ground black, greasy, and fetid. They saturate it, as it were, with these products of putrefaction, until the dissolving power of water and air, the vaporization effected by heat, and the absorption by vegetables, deprive the ground of the fluids with which it is impregnated. Thus it is that nature, by slow decompositions, reduces the bodies of animals deprived of life, to more simple substances destined to enter into new combinations.

This decomposition, considered on every part of the globe at once, in the earth, in the water, or in the air, produces great changes, which the philosopher ought to appreciate. By observing the vast extent of the seas, and the immense quantity of animals which inhabit them, we perceive those animals perish in enormous masses, and suffer a decomposition, which produces phenomena hitherto not sufficiently examined. What become of the immense remains of animal matters? To what

ſucceſſive revolutions are theſe ruins of living beings expoſed? It is known that the waters of the ſea contain the muriats and ſulphats of ſoda, of lime, and of magnesia. It cannot be doubted, but the muriatic acid, magnesia, lime, and ſoda, are continually formed in this vaſt laboratory. Perhaps the formation of many of theſe ſubſtances may take place during the life of theſe marine animals; but ſome others are certainly owing only to the decomposition of the ſame ſubſtances after death. It cannot be denied, that the ſtrata of calcareous matters, which conſtitute as it were the bark or external covering of the globe, in a great part of its extent, are owing to the remains of the ſkeletons of ſea animals, more or leſs broken down by the waters; that theſe beds have been depoſited at the bottom of the ſea; that ſuch is likewiſe the origin of bitumen, and more eſpecially pit-coal, which is depoſited in very thin and extended ſtrata, which likewiſe occupy a part of the globe. There is therefore, in the ſea, a never-ceaſing cauſe of the decomposition of water: numberleſs agents continually ſeparate its principles, and are themſelves changed. Immenſe maſſes of chalk, depoſited on its bottom, abſorb and fix the water, or convert into a ſolid ſubſtance, part of the liquid which fills its vaſt baſons.

From theſe conſiderations reſpecting the decomposition of animal ſubſtances in the earth, in the air, and in the water, united to all the data afforded by chemiſtry, it follows, that the external ſtrata of the globe are no longer what they were at the moment of its formation; that it increaſes in ſolidity and extent by the ſucceſſive and uninterrupted augmentation of theſe depoſitions; that the ſoil we inhabit is modern and factitious; that it does not belong to minerals; that this ſuperficial ſoil is owing to the ſlow decomposition of animals and vegetables; that water is continually diminiſhed in quantity, and changes its form; that one part being decompoſed, furniſhes one of the baſes of the bodies of vegetables and animals; that another part is rendered ſolid in the calcareous ſtrata added to the globe; that the atmosphere muſt have been modified by all theſe ſucceſſive changes; that vegetables continually influence the atmospheric air; and that the ſolar light is greatly concerned in all theſe mutual decompoſitions. Though it

seems impossible to determine the times which have successively beheld the decomposition of water, vegetation, fermentations, putrefaction, the formation of saline substances, bitumens, calcareous matters, and the modifications of the atmosphere; yet philosophy and chemistry, enriched by modern discoveries, show us at least that these phenomena have taken place at different epochs; that they continue to modify the actual state of the planet we inhabit; and that if matter be one and the same thing, with respect to its mass and intimate nature, as great philosophers have thought, yet its form being continually varied by the combinations it experiences, must gradually produce great revolutions, of which modern chemistry alone can appreciate the cause, and of which perhaps it may some day foretell the final effects.

OF THE

METHODICAL CLASSIFICATION,

AND THE

NATURAL HISTORY OF ANIMALS.

THE number of animals which cover the surface of our globe being very considerable, it would be impossible to distinguish them from each other, if nature had not presented remarkable differences in their external figure, on which distinctions are easily established. Naturalists have at all times been sensible of the utility of these differences, which they have advantageously applied in classing animals into methodical divisions. Although it is certain, that these classifications do not exist in nature, but that the whole chain of created beings is uninterrupted, yet it is certain, that these methods assist the memory, and are of great use in the study of natural history. We may therefore consider these methods, as instruments appropriated to our limited powers, by the help of which we may successfully attend to the riches of nature. Aristotle established only general and simple divisions; but his masterly considerations, respecting the interior and exterior organs of animals, have formed a base, on which the divisions of the first naturalists, such as Gesner, Aldrovandus, Jonston, Charleton, Ray, &c. are in great part founded. These early naturalists have been succeeded by a great number of others, who have rendered the methods more perfect, and have added to the knowledge we possess: but among these last, those whose works more particularly require to be known, and from whom we shall bor-

row, are Messrs. Klein, Artedi, Linnæus, Brisson, Daubenton, and Geoffroy.

After man, whose organization and intelligence place him at the head of animated bodies in a separate class, all other animals may be divided into eight classes; namely, quadrupeds, cetacea birds, oviparous quadrupeds, serpents, fishes, insects, worms, and polypi.

These classes might be more multiplied, but the difficulties would increase in the same proportion, and defeat the purpose of artificial classification, whose sole merit consists in simplicity and perspicuity. Daubenton, who has paid great attention to the classification of animals, has arranged them in the same manner, and has considered the structure of the principal constituent parts of each, to show that the classes are gradually degraded, from quadrupeds, which nearest resemble man, to worms, which are the most remote. As there are two principle objects of attention in the history of animals, 1. Their external forms, and the methods founded on these forms. 2. Their internal organs, and the functions for the performance of which they are destined. We shall consider each of these objects in separate sections.

SECTION I.

A SKETCH OF THE DIFFERENT SYSTEMS OF THE NATURAL HISTORY OF ANIMALS.

ARTICLE I.

Concerning Quadrupeds.

ZOOLOGY.

QUADRUPEDS are animals having four feet, whose body is most commonly covered with hair. They respire by lungs similar to those of man; and like him they have a heart, consisting of two ventricles: they are viviparous. These animals resemble man the nearest in their structure; there are even some,

as for example, the ape, and a few others, which Linnæus has thought proper to include in the same order as man. This naturalist gives the name of *mammalia* to this class, in which he comprehends cetaceous animals, because they have teats, and give milk to their young. Though this class of animals appears to resemble man in some respects, yet they differ greatly from him in several important particulars. Such are the horizontal situation of their bodies, the form of their extremities, the thickness and hardness of their skin, which is hairy, or covered with a hard, and, as it were, corneous substance, the prolongation of the vertebræ of the back into a tail, the anterior part of the cranium flat and horizontal, the ears large and long, the bones of the nose and upper jaw very long, and placed obliquely. When we compare this structure to that of the human species, whose body is perpendicular, the bone called radius moveable, the fingers perfectly separate, the thumbs opposed to the four other fingers, and the skin smooth and thin, we shall be sensible how much this confirmation exalts its sensibility, and renders it superior to the most perfect of other animals. The anatomy of its internal parts, and the history of its functions, add still more force to those important conclusions.

The ancient naturalists, at whose head Aristotle and Pliny may be placed, have distinguished quadrupeds only by the place of their habitation. For which reason, and the want of accurate descriptions, it is often impossible to ascertain the animals they speak of. Later naturalists, perceiving the disadvantages of this method, adopted another, which is very different: they have availed themselves of the most obvious differences on the external parts of animals, to establish characters readily known, by the assistance of which they may with certainty be distinguished from each other. We shall in this place explain three artificial methods of classing quadrupeds; namely, those of Linnæus, Klein, and Brisson.

The Method of Linnaeus.

Linnæus has divided animals with teats, or the *mammalia*, in seven orders. The first, comprehending those which he calls *primates*, has for its characters incisive teeth in both jaws;

constantly four in number in the upper jaw ; two teats on the breast, and the arms separated by claviculæ : this order contains four genera ; man, *homo* ; the ape, *simia* ; the lemur, or *prosimia* ; and the bat, *vespertilio*. It cannot but be admitted that this method is very remote from nature, since it arranges in the same order, creatures so dissimilar as man and the bat.

Animals of the second order are distinguished by the name of *bruta* ; their characters are the want of incisive teeth, feet armed with strong hoofs, and a slow pace. This order includes six genera, which are the elephant, *elephas* ; the sea-cow, *trichecus* ; the sloth, *bradypus* ; the ant-eater, *myrmecophaga* ; the ——— *manis* ; the tatow, *dasyurus*. The two first genera are very remote from the four others.

In the third order, the Swedish naturalist distinguishes savage beasts by the name of *feræ*. In this he comprehends all animals with teats, whose incisive teeth are conical, and usually six in number in both jaws, whose canine teeth are very long grinders, not flattened, feet armed with sharp nails, and which tear their prey, and live by destroying other creatures. There are ten genera of this order ; the seal, *phoca* ; the dog, *canis* ; the cat, *felis* ; the ferret, *viverra* ; the weazel, *mustela* ; the bear, *ursus* ; the opossum, *didelphis* ; the mole, *talpa* ; the shrew-mouse, *orex* ; and the hedge-hog, *erinaceus*.

The fourth order, entitled *glires*, or rats, is distinguished by the following characters : the animals which compose it have two incisive teeth in each jaw, and no canine teeth ; their feet are armed with claws proper for leaping ; they live on barks, roots, &c. This order comprehends six genera ; namely, the porcupine, *hystrix* ; the hare, *lepus* ; the castor, *castor* ; the rat, *mus* ; the squirrel, *sciurus* ; and the American bat, to which Linnæus has given the name of *noctilio*.

In the fifth order, he includes, under the name of *pecora*, such quadrupeds as have incisive teeth in the lower jaw, and none in the upper ; whose feet are cloven, and which ruminates. The camel, *camelus* ; the musk animal, *moschus* ; the stag, *cervus* ; the goat, *capra* ; the sheep, *ovis* ; the ox, *bos* ; are the six genera which compose this order.

The sixth order includes, under the denomination of *belluæ*, such quadrupeds as have the incisive teeth obtuse, and their

feet hoofed. The four genera of this order, namely, the horse, *equus*; the hippopotamus, *hippopotamus*; the hog, *sus*; and the rhinoceros, *rhinoceros*, are very well distinguished from each other by the number of their teeth, and the form of their feet.

Lastly, The seventh order, which comprehends the cetaceous animals, is distinguished from all others by the form of the feet, which resemble fins: but as we think proper, with many modern naturalists, to make a peculiar class of cetaceous animals, we shall speak of them after quadrupeds.

The method of Linnæus appears to be defective in many respects; not only in its arranging together animals so dissimilar as man and the bat, &c. and separating animals so similar as the rat and the mouse, &c. but likewise because the divisions are not sufficiently numerous, and do not readily enable us to distinguish each quadruped; which last requisite is indispensably necessary, and is in fact the only advantage a method is required to possess.

The Method of Klein.

Klein divides quadrupeds into two principal orders: in the first, he arranges those whose feet are ungulated, *pedes ungulati sive cheliferi*; in the second, those whose feet are digitated, *pedes digitati*.

The first order is divided into five families, whose characters are founded on the division of their ungulated feet in several pieces. The first family, called *monochela*, comprehends the genus of the horse: the second, whose individuals are distinguished by the name *dichela*, includes all those whose feet are cloven into two parts, *bifulci*. Some have horns, as the bull, the ram, the goat, the stag, &c. others are not horned, as the hog, the boar, the bayroussa. The *trichela*, or animals whose ungulated feet are divided into three parts, compose the third family, of which the rhinoceros is the only variety. The fourth family, whose character consists in the feet being divided into four pieces, *tetrachela*, contains only the hippopotamus. The fifth, which is distinguished by the feet being divided into five parts, *pentachela*, includes only the elephant.

The second order of quadrupeds, whose feet are digitated, is likewise divided into five families; the first comprehending animals with two digits, *didactyla*, consists of the camel and the sloth, or sloth of Ceylon. The second family, or animals of three digits on their feet, *tridactyla*, includes the sloth and the ant-eater. The third, *tetradactyla*, or animals of four digits, contains tatous, or armadillos, and Guinea pigs, which seem to be a species of rabbits. The fourth family, characterized by five digits on the feet, *pentadactyla*, is the most numerous of all; it contains the rabbit, the squirrel, the dormouse, the rat and the mouse, the opossum, the mole, the bat, the weazel, the porcupine, the dog, the wolf, the fox, the coati, the cat, the tiger, the lion, the bear, and the ape; the number of species comprehended under these genera is very considerable. It must be observed, that in all these characters, taken from the form of the feet, Klein considers only the fore feet in his distinction of families. Lastly, The fifth family consists of animals whose feet are irregular, *anomalopodia*; such are the otter, the castor, the sea-cow, and the seal.

The same objection may be made to the system of Klein, as to that of Linnæus. Though his first divisions are sufficiently distinctive of the families, the genera are not so easily ascertained according to his method, more especially those of the fourth family.

The Method of Brisson.

Brisson has avoided most of these inconveniences, by combining together all the characters used by the naturalists who have preceded him. He has availed himself of the number of teeth, or their absence, the form of the extremities, that of the tail, the nature of the appendices, such as the horns, the scales, the prickly spines or quills. His combined method is doubtless the most complete, and best adapted to distinguish any quadruped, and refer it to its proper genus. We here present his divisions in the form of a table; it exhibits the characters of these animals to their respective genera, and has the advantage of being very simple, and easily understood. See Table II. at the end of this Volume.

ARTICLE II.

Concerning Cetaceous Animals.

Cetaceous animals are of a large size, inhabit the ocean, and by the structure of their lungs and blood-vessels, are capable of living in water, as we shall more fully explain in the history of respiration. They resemble quadrupeds in the structure of their breasts, and in general of all their internal organs, as well as in their bringing forth living young. But they differ from them in the form of their extremities, which terminate in fins, and in two large apertures, at the upper part of their heads, through which they cast up the water to various heights. Naturalists call these passages *spiracula*, which word Daubenton translated by that of *vents*. The number of genera of these animals is much less considerable than that of quadrupeds. Brisson has distinguished them, 1. Into such as have no teeth, as the whale, *balena*. 2. Into such as have teeth only in the upper jaw, as the *monodon*, *vel monoceros*. 3. Such as have teeth only in the lower jaw, as the narval, or sea-unicorn, *physter*. 4. and lastly, Such as have teeth in both jaws, as the dolphin, *delphinus*.

ARTICLE III.

Concerning Birds.

ORNITHOLOGY.

Birds are biped animals, which move through the air by means of wings, are covered with feathers, and have a beak of a horny substance. A great number of interesting facts are observable with regard to these animals, relative to the various form of their beak, the structure of their feathers, the motions they perform, and their manners or habits. The most important of these will be exhibited in the abridgment of Physiology, which we shall give in the following pages; but at present we shall only attend to the external characters which naturalists have taken to distinguish birds, and class them methodically. The earlier writers on this part of natural history have established no other differences between birds than such

as relate to the places they inhabit. Hence they have distinguished them into birds inhabiting woods, plains, seas, rivers, lakes, &c. Others have distinguished them from their food, into birds of prey, granivorous birds, &c. &c.

But methodical writers have distinguished birds in another way. Linnæus has divided them after the form of their beak into six orders, like the quadrupeds with which he has compared them. But these divisions do not appear sufficiently extensive, especially when we consider that the number of species in birds is much more considerable than in quadrupeds, since Buffon reckons the quadrupeds at two hundred, and the birds at fifteen hundred or two thousand. We shall therefore only mention in this place the methods of Klein and of Brisson.

Klein divides birds into eight families, after the form of their feet; the first under the name of *didactyles*, comprehends such as have two digits on their feet; the ostrich is the only species in this division. The second contains the *tridactyles*, such as the casuary, the bustard, the lapwing, and the plover. The third contains the *tetradactyles*, which have two digits behind and two before; such as the paroquet, the wood-pecker, the cuckoo, and the king-fisher. The fourth contains the *tetradactyles*, three of whose digits are before, and one behind. This family is the most numerous of any, as it comprehends the birds which prey by day and night, such as the raven, the magpye, the starling, the thrush, the blackbird, the lark, the redbreast, the swallow, the titmouse, the woodcock, &c.

The fifth family contains the *tretradaçtyles*, whose three anterior digits are united by a membrane, and the posterior at liberty. These birds are called *palmipedes*; the goose, the duck, the sea-maw, and the diver, compose this family. The sixth includes the *tetradactyles*, whose four digits are united by a membrane. These in Latin are called *planci*. The pelican, the cormorant, the booby, and the anhinga, are arranged by Klein in this family. The seventh is composed of such as have only three digits, and these united by a membrane; they are called the *tridactyles palmipedes*. The guillemot, the penguin, and the albatros, belong to this family. Lastly, The eighth class includes the *tetradactyles*, whose digits have membranes fringed, or as it were torn; these are also called *daçtylobes*.

Coots, and some of the species of divers, compose this last family. The method of Klein, though more comprehensive than that of Linnæus, is, notwithstanding, attended with many difficulties in ascertaining the genera, especially that of the fourth family; for which reason we think the method of Brisson is to be preferred. It must be confessed, however, that this last, in which the author has used all the characters together, as he has done with respect to the quadrupeds, appears very complicated at first sight; but when it is reduced into a table, as we have done, all its divisions may be readily distinguished; and any bird may be easily known by attending to the characters according to the arrangement. See Table III. at the end of this volume.

ARTICLE IV.

Concerning Oviparous Quadrupeds.

Linnæus classed together, in his system, under the denomination of *amphibia*, the oviparous quadrupeds, serpents, and cartilaginous fishes: but Daubenton observes, that the word *amphibious* cannot be applied to any peculiar class of animals; because, if the expression be applied to animals who live as long as they please either in the air or in the water, there are none which possess that advantage; and if it be applied to terrestrial animals, which are able to remain a certain time in the water, or to aquatic animals, which are capable of living a certain time in the air, all animals would be amphibious. He therefore makes two orders of oviparous quadrupeds and serpents, and arranges the *amphibia nantes* of Linnæus among the fishes.

The oviparous quadrupeds form the fourth order of animals in the division of Daubenton. Their organization is considerably perfect, since, like the quadrupeds, cetaceous animals, and birds, which precede them, they have a head, nostrils, and internal ears. But they differ in the following characters: 1. They have but one ventricle in the heart. 2. Their blood is almost cold. 3. They inspire and expire the air at long intervals. 4. They are oviparous, and consequently without

breasts; this last character is common to them with the four orders of animals which follow them. Lastly, The existence of four feet without hair, is peculiar to this order.

Daubenton remarks, that the several genera of this order of animals differ too much from each other, to admit of any general description applicable to the whole. He therefore applies the general characters in the history of each genus; as for example, at the words tortoise, lizard, toad, frog, &c. in the second volume of the *Natural History of Animals*, which composes part of the *Encyclopédie Méthodique*.

As the methodical disposition, and the characters of the orders of oviparous quadrupeds, as laid down by this celebrated naturalist, are the most accurate and complete of any which have yet come under my observation, I have united all the divisions of Daubenton from the classes to the species; because these last are no more than a hundred in number. See Table IV. Since the publication of Daubenton's work, *La Cépède* has published a very complete and accurate work on oviparous quadrupeds, in which he has exhibited a peculiar mode of arrangement. This method is laid down in Table V. which is extracted from Cépède's work.

ARTICLE V.

Concerning Serpents.

Serpents form the fifth order of animals in the division of Daubenton. The scales with which they are covered, and the absence of feet and fins characterize them very well. They have a head, nostrils, internal ears, a single ventricle in the heart, the blood almost cold, their respiration is made at long intervals, and they lay eggs like the oviparous quadrupeds. Serpents have neither neck nor shoulders, and the scales which cover them are of three kinds. They are either rhomboidal, and cover each other in the manner of tiles, which Linnæus calls *squamme*; or they are of a long form, touching without covering each other; Linnæus calls these *scuta*, they are only observed on the under part of serpents; when they are very small, and of the same form, they are called *scutella*; or lastly,

they consist of rings encircling the bodies of serpents, as is seen in the amphisbena.

Serpents, though without feet, sometimes move with considerable swiftness, by leaning first on their anterior part, raising up the middle, and bringing forward the posterior part of their body; by which means they raise themselves on their tail, and spring to some distance, in order to seize their prey. They cast their skin once or twice in the year.

Some serpents are venomous; out of 131 species noted by Linnæus, 23 are dangerous, according to that naturalist. All these animals, whose bite is venomous, have on each side of the upper jaw, a tooth much larger than the others, together with a reservoir filled with a peculiar liquor, which passes into the wound through a perforation in the tooth.

It is established, by the most authentic testimony, that some serpents are of a prodigious size. Mr. Adamson, from very exact data, fixes the magnitude of the largest serpents at 40 or 50 feet in length, and a foot, or a foot and a half in thickness.

Laurenti has paid greater attention than any other naturalist to the classification of serpents. He distributes them into seventeen genera; but the difficulty of observing the distinctive characters, has prevented Daubenton from adopting his method; this last naturalist has therefore adopted Linnæus's method. I have inserted the divisions and character's of serpents from the genera to the species noted by Daubenton in Table VI. La Cépède has likewise published a method for arranging serpents, but the length of the table which contains it, renders it impossible for us to insert it in this work.

ARTICLE VI.

Of Fishes.

ICHTHYOLOGY.

Fishes are animals very different from the foregoing: their interior organs are of peculiar structure, as we shall observe in our abridgment of physiology. They are distinguished from other animals by their having no feet, but fins, by which they

move in the water, and by their respiring water instead of air. It is much more difficult to make observations on fishes than on other animals, and for that reason their natural history is in a much less advanced state.

In order to understand the methodical division which we propose after Artedi, Linnæus, and Gouan, it will be necessary to take a cursory view of the anatomy of their external parts. The bodies of fishes may be divided into three parts; namely, the head, the trunk, and the fins.

The head of these animals is differently formed. It is either flattened horizontally, or laterally, or else round; naked, or covered with scales; smooth, or covered with asperities, tubercles, &c. Their mouths are observed to have lips either of flesh or of bone, with appendages, or soft and very moveable barbulæ; the teeth fixed either to the jaws, the palate, the tongue, or the throat; the eyes, two in number, motionless, and without eyelids; the perforations of the nostrils double on each side; the opening of the gills or branchiæ; the opercula, or round triangular or square bones designed to close the aperture of the branchiæ; the branchial membrane placed beneath the opercula, sustained by several bones in the form of an arch, whose number varies from two to ten. This membrane is folded up beneath the opercula, and must be well examined with respect to its structure and varieties, because the characters of the genera are most commonly taken from the number or form of its radii.

The trunk is of various forms as well as the head; it is either round, globular, long, flat, or angular. The observer must take notice of the lateral line, which seems to divide each side of the body into two parts; the thorax, placed beneath the gills at the commencement of the trunk, and containing the heart and the branchiæ; the belly, whose ribs form the principal supports of the fins continued from the head to the tail, and which contains the stomach, the intestines, the liver, the air bladder, the parts of generation; the opening of the anus, which is common to the intestines, the bladder, and the generative parts; lastly, the tail, which terminates the trunk, and is of various forms and magnitudes.

The fins, *pinna natatoria*, are formed of membranes support-

ed on small radii, some of which are hard, bony, and terminate in a sharp point, which characterizes the fishes called *acanthopterygiani*, so denominated by Artedi; others are flexible, soft, obtuse, and, as it were, cartilaginous, which characterizes the fishes called *malacopterygiani*. Five sorts of fins are distinguished with respect to their situation; the dorsal, the pectoral, the abdominal, together with those of the anus, and of the tail.

The dorsal fin is impair; it maintains the fish in equilibrium, and varies in situation, number, figure, proportion, &c.

The pectoral fins are situated at the aperture of the gills; they are two in number, and perform the office of arms, and sometimes of wings. They differ as to the place of their insertion, extent, figure, &c.

The abdominal fins are of the greatest importance to be known, because their situation has been assumed by the celebrated Linnæus, as a distinctive character in the classification of fishes. These fins are placed at the inferior part of the body, under the belly, before the anus, always lower and nearer to each other than the pectoral fins. They are sometimes wanting; and as Linnæus has compared them to feet, he calls those fishes that are without them *apodes*; but they exist in the greatest number of fishes. Their insertion varies; when they are placed forward or beneath the aperture of the gills, and the pectoral fins, they are called *jugular*; and the same name is likewise applied to the fishes in which it occupies this place. If they be attached to the thorax behind the opening of the gills, they are then called *thoracic*; and the fishes which possess this structure, are distinguished by the same name in the method of Linnæus. Lastly, When they are placed beneath the belly, nearer the anus than the pectoral fins, they are denoted by the name of *abdominal*, which term is likewise applied to the fishes distinguished by this structure.

The fin of the anus is impair. It occupies either wholly, or in part, the region situated between the anus and the tail; it differs in form, extent and number, though it has not been observed double, excepting in the gold fish of China.

The tail fin is placed vertically at the extremity of the body, and terminates the tail. It is the rudder of the fish, or instru-

ment, by the various motions of which it changes its direction at pleasure. It likewise exhibits many varieties in its form, adherence, connection, extent, &c.

After these details respecting the external anatomy of fishes, we shall proceed to mention the methodical divisions of naturalists. Before the time of Artedi, no naturalist had attempted to arrange fishes in a methodical manner; though several methods were before used for the classification of other animals. This philosopher proposed a system of Ichthyology, founded on the nature of the bones of the fins, whether hard or soft, pointed or obtuse, and on the form of the gills. He afterwards attempted to multiply the divisions, by attending to the other parts; but a premature death terminated his labours. Linnæus attempted to establish an Ichthyologic method, from the various situations of the belly fins; and Gouan, a celebrated professor at Montpellier, has very skilfully combined the two systems of Artedi and Linnæus. This naturalist first divides fishes into such as have their gills complete; that is to say, consisting of an aperture and a complete branchial membrane, and those which have their gills imperfect, that is to say, wanting either the opercula, or the branchial membrane, or both. The first are afterwards distinguished from each other by the form of their fins. These parts are in fact composed either of hard and sharp bones, or soft, and, as it were, cartilaginous radii. These differences constitute three classes of fishes, namely, 1. The acanthopterygiani. 2. The malacopterygiani. 3. The branchiostegi. In each of these classes of fishes, the belly fins are either wanting, or placed at the neck, thorax, or belly. Gouan has divided each class into four orders; that is to say, apodes, jugular, thoracic, and abdominal.

The distinctive characters of the genera, which immediately follow these divisions, are founded on the form of the head, of the mouth, of the branchial membrane, and more particularly on the number of radii which support this membrane. See Table VII.

ARTICLE VII.

Concerning Insects.

ENTOMOLOGY.

Insects are animals which are known by the form of their body, which is divided, as it were, into rings, and by two moveable horns which they have on their head, and are distinguished by the name of *antennæ*. Insects compose one of the most numerous classes of animals, doubtless, on account of their minuteness; for it has been observed, the smaller these creatures are, the more numerous is their production. The history of these animals is highly agreeable and amusing, and perhaps not the least in point of utility; since discoveries respecting their properties may prove useful in the arts, and in medicine.

The classes of insects exhibit resemblances with almost every other animal, with respect to their manners, form, habitations, &c. Some walk like quadrupeds, others fly like birds, others again swim, and live in the water like fishes; and lastly, there are others which leap, or crawl along, like certain reptiles. This analogy may even be carried much farther, by a full examination of the structure of their extremities, their mouth, their internal organs, &c.

Insects externally considered, are composed of three parts; namely, the head, the thorax, and the abdomen.

The head differs in its form, size, and position. It is sometimes very large, and sometimes very small, with respect to the bulk of the insect. It is either round, square, or long; smooth, rough, tuberculated, or tufted with hair. We may observe, 1. The antennæ placed near the eyes, consisting of different articulated and moveable pieces, resembling a thread terminated either by a point or a knob. The form of these organs must be carefully distinguished, because this character is almost always used to distinguish the genera. 2. The eyes, which are of two sorts, either in facets, or resembling network, smooth and small. These organs are very large in some insects, and in others very small. Their number is various;

there are insects which have only one eye, as the monocus; others have two, five, or even eight, as for example, the spider, &c. 3. The mouth, which is formed either of strong and corneous jaws, moveable laterally, or consists of a trunk of various lengths, dilated; spiral, &c.; or a simple cleft, &c. This part is frequently ornamented with small moveable appendices, called antennulæ, to the number of two or four.

Fabricius has examined very carefully the different parts of the mouths of insects; and he has made use of the variety which they exhibit, in forming a new system of insectology. See Fabricius's works, particularly his *Genera Insectorum*.

The thorax is the stomach of insects. It is placed between the head and the belly, and is either round, triangular, cylindric, thick, slender, &c. It may be considered as composed of six faces, like a cube, which form it sometimes has. The face, or anterior extremity, is hollowed to receive the head. This articulation is sometimes made only by a part as small as a thread, as in flies. The posterior extremity is usually rounded and articulated with the first ring of the abdomen, and is sometimes joined with this part only by a thread. The superior surface is either flat and smooth, rounded, prominent, with appendices, or tubercles, or terminated by a kind of border, turned up, which constitutes the *thorax marginatus*. The wings are attached at the posterior part of this surface. Most insects are provided with these organs; but as they differ singularly from each other, and the principal divisions of classes adopted by methodical writers are founded on these differences, it will be necessary to attend more particularly to them.

The wings are either two or four in number; among those which have two transparent wings, are the fly, the gnat, &c. these wings always have beneath the place of their insertion a slender thread terminated by a round button, called the balancer, *halter*, which is covered by a concave membranous substance called the *bowl*. In a great number of insects these two wings are very strong, and folded up under hard, horny, moveable coverings, called sheaths, or *elytra*. These differ in form; some cover the whole abdomen; others are, as it were, cut transversely, and cover only a part; some are hard, and others soft, and most of them towards the top of the future, or line, at which they are applied to each other, have a small

triangular piece affixed to the thorax, which is called *scutellum*; but this piece is wanting in some. Lastly, In many insects the elytra are fastened together, and are formed of one motionless piece.

The wings are often four in number, and are thin, membranous, and transparent, as in the libella, the wasp, &c. or they are covered on each surface with a coloured powder, which, under the microscope, appears to consist of scales, placed over each other like tiles, *imbricatum*.

The inferior part of the thorax is irregular, consisting of several pieces fastened to each other: and some of the legs are fixed to it. The number of legs varies in insects; some have six, and others eight, like spiders: others have ten, as the hornet. Lastly, There are insects which have a much larger number; the wood-lice have sixteen; and some species of scolopendra, and centipedes, have as many as seventy, and one hundred and twenty, on each side. Among those which have no more than six, eight, or ten, they are all attached to the thorax, according to Geoffroy; among those which have a larger number, some are inserted in the rings of the belly.

The leg of an insect is always composed of three parts; the thigh, which joins to the body, the leg, and the tarsus. There is often an intermediate piece between the body and the thigh. The tarsus is formed of many pieces, or rings, articulated together, whose number varies from two to five. In some insects, the tarsus is more considerable in the fore than in the hind feet; a circumstance which established an analogy between these creatures and many quadrupeds, whose fore-feet have a greater number of digits than the hinder. Geoffroy has availed himself of this character, in his division, as we shall hereafter see. The tarsus is terminated by two, four, or six, small claws, or hooks, and is often furnished with brushes, or spongy balls, on its lower part, by means of which the insect is capable of walking on the most polished substances, such as glass, &c. in any position.

On each side of the thorax, one or two oblong, oval apertures, are observed, which are called *stigmata*, through which the insect respire.

The third part of insects is the abdomen. It is most com-

monly composed of corneous rings, or half rings, which slip over one another; in some the rings are not observed, and the abdomen appears to be formed of a single piece: it is usually larger in females than in males. The parts of generation are placed at its extremity; a stigma is observable on the side of each ring, except the two last. Many insects have stings at the posterior part of their abdomen, some of which are sharp and piercing, others in the form of a saw, and some of that of a gimblet. They serve either as instruments of defence, or to penetrate substances in which the insects deposite their eggs.

The most singular phenomenon, in which insects differ entirely from most other animals, consists in the changes of state through which they pass, or the metamorphoses they are subjected to, before they become perfect insects. There are some insects, and almost all the class of aptera, which do not undergo these changes, but the greater number are subject to them; the insect does not come out of the egg with the form of the mother, but in that of a worm, with or without feet, the structure of its head and the rings being exceedingly various. This first state is the caterpillar; under this kind of mask, the insect eats, grows, moves, and changes its skin several times. When it has grown to its full size, it changes its skin for the last time, and no longer appears under the form of a worm, but under a different form, called *nympha chrysalis, aurelia*.

Geoffroy distinguishes four kinds of nymphæ: the first is that which does not resemble an animal; a few rings only are observed at the lower part, and the upper part exhibits indistinct impressions of antennæ, legs and wings. The skin of this kind is hard, cartilaginous, and it has only a slight motion in its rings. The butterfly, phalæna, &c. are of this kind.

The second kind of chrysalis admits of the parts of the perfect animal being distinguished beneath a thin and very soft skin. It is motionless, like the foregoing. Insects with hard coverings to their wings, those with four naked wings, and those with two wings, afford examples of this kind.

The third species, is that whose parts are perfectly developed, and which move; such are those of the gnats and insects which pass the two first stages of their life in the water.

Lastly, The fourth species comprehends those which resemble the perfect insects in the form of their body, their antennæ, and paws: these nymphæ move, and eat: they differ from perfect insects only in the want of wings, and in their being incapable of procreating. The nymphæ of the libella, of the bug, of grasshoppers, and of crickets, &c. are of this kind.

Insects, like other animals, were only distinguished by the ancient naturalists from the places of their habitation. No one, before the time of Linnæus, attempted to dispose them methodically, according to distinguishing characters. After Linnæus, to whom we are indebted for the first systematic division of these animals, Geoffroy attempted to class them in a more accurate manner; his division of sections in genera is a masterpiece of this kind, for precision, accuracy, and perspicuity. He divides insects into six sections, according to the absence, the number, and the structure of the wings: the first section includes the *coleoptera*, or insects whose wings are covered with cases. Their mouth, which is armed with two lateral and corneous mandibles, forms likewise a general character of this section. The May-bug exhibits both these characters. Although several celebrated naturalists have turned their attention to insects since the time of Geoffroy, and although Fabricius has published a new system for the classification of insects founded on the organs with which they receive their food, which contains much more genera and species than that of Geoffroy, I have not thought it necessary to publish it, because it is infinitely more complicated and embarrassing for the young student.

The second section comprehends the *hemiptera*, whose superior wings are either in a small degree thick and coloured, or rather hard and opaque; but as the character of the wings is not strongly marked in this section, it is replaced by that of the mouth, which is constant. This mouth is a long and slender trunk, turned inwards between the feet: the wood-bug and the cicada are of this section.

The third section is composed of *tetraptera*, with farinaceous wings, the four wings being coloured by a scaly powder. These have a trunk more or less long, and often of a spi-

ral form, as in the butterfly: Linnæus calls these *lepidoptera*.

In the fourth section are placed the *tetraptera*, with bare wings. Their four wings are membranous, and their mandibles are hard: the wasp is of this kind. Linnæus has made two orders of these insects; namely, the *neuroptera*, whose anus has no sting, and whose wings have nervous marks; and the *hymenoptera*, which have the anus armed with a sting, and the wings membranous, without any very apparent nerves.

The fifth section contains the *diptera*, or insects with two wings; their mouth is most commonly in the form of a trunk, and they have balancers under the insertion of their wings.

Lastly, In the sixth and last section are classed, the *aptera*, or insects without wings, such as the spider, the louse, &c.

Besides these primary divisions, Geoffroy has established others, to facilitate the distinction of insects. See Table VIII.

ARTICLE VII.

Of Worms.

HELMINTOLOGY.

Worms are soft animals, of a very different form from insects, with which they have been confounded by several naturalists, their organization being less perfect than that of those animals. They have no bones, properly speaking; and their members are not constructed like those of insects, neither are they, like them, subject to pass through different states. Their organs, destined for the purpose of generation, are not known; many worms have no head perfectly formed; and lastly, the absence of feet and scales distinguishes them from all other creatures. The class of worms is the most numerous, and the least known, of all animals. There are few organic substances, either living or dead, in which certain worms are not found, that subsist and are nourished within them. Most naturalists have placed worms and polypi in the same class; but it would perhaps be better to separate them, since their internal structure and functions perfectly distinguish them from each

other. We know that most worms contain a heart, and vessels, but nothing similar has been discovered in polypi. The worms we now speak of must not be confounded with the *larvæ* of insects or caterpillars, which have likewise been called worms, merely on account of their form. Their head, furnished with mandibles, and their legs, which are more or less numerous, consisting commonly of six, afford characters by which they may be easily distinguished.

Worms have a considerable degree of activity, and in general love moisture. Some have not a head which can be easily distinguished; most of them are hermaphrodites. Such as have a head, have two moveable horns, which they can retract, and are called *tentacula*. All the worms, of which we are now giving an abridged account, have the property of being reproduced, when cut through; a circumstance which shows, that their organization is simple, and resembles that of polypi.

This class of animals might be divided into four sections: the first would contain the naked, or bare worms, whose organization is best known, and which in their leading character resemble other animals; in the second, we might place worms which have a testaceous covering, or shell-worms; their organs are less known than those of the former section; the valuable researches of Mr. Adanson prove, however, that their structure resembles that of naked worms. The third section would contain worms with a crustaceous covering; their organization is not so well known as that of the foregoing, their external form, and the structure of their mouth, only having been examined. And lastly, The fourth section would include the polypi. The methodical divisions of these different sections have already afforded employment to many naturalists; Lister, Linnæus, Klein, Ellis, Pallas, D'Argenville, are those of whose assistance we have availed ourselves, in the imperfect division exhibited in the ninth table of the former edition. Since that period, Brugnier, who has paid great attention to this branch of the natural history of animals, and who is intimately acquainted with the structure of worms, has published, in the *Encyclopédie Methodique*, a *System of Classification*, which we have thought proper to adopt and exhibit. See Table IX.

SECTION II.

THE FUNCTIONS OF ANIMALS CONSIDERED, FROM MAN TO THE POLYPUS.

THE characters peculiar to living and organized bodies, consist, as we have already observed, in the different functions executed by means of their organs. We have considered those of vegetables; the order we have adopted now leads us to the functions of animals.

That branch of science, in which the functions of animals are examined, is called physiology. This useful and valuable science ought not to be confined to the single consideration of the human species, but it should be extended to all animals: in this point of view, we shall cursorily pass over the animal kingdom.

The functions of animals are reducible to the following:

- I. Circulation.
- II. Secretion.
- III. Respiration.
- IV. Digestion.
- V. Nutrition.
- VI. Generation.
- VII. Irritability.
- VIII. Sensation.

These different functions are observed in man, quadrupeds, cetaceous animals, birds, fishes, oviparous quadrupeds, serpents, and insects. Worms and polypi do not possess them all, neither do serpents nor insects possess them in the same degree.

ARTICLE I.

Concerning Circulation.

The circulation is one of the most important functions. It is indispensably necessary to maintain life. The organs by which it is performed, are the heart, the arteries, and the veins.

The heart is a conical muscle, towards the apex of which

are two cavities, called ventricles ; and at its base, two other vessels, called auricles. A large artery, named the aorta, issues from the left ventricle, and distributes the blood to the various parts of the body ; another artery, of equal magnitude, issues from the right ventricle, which is called the pulmonary artery, because it is spread into ramifications in the lungs. The right auricle receives the blood which returns from every part of the body, by the two venæ cavæ ; whence the fluid passes into the right ventricle : from this last it is transmitted to the lungs, by the pulmonary artery, and is returned, by the pulmonary veins, into the left auricle, and thence to the left ventricle, from whence it is propelled to all the parts of the body through the aorta. This motion, as it takes place in man, constitutes two kinds of circulation ; that of the whole body, and the pulmonary circulation. The latter was known before the former. Harvey, an English physician, discovered the general circulation.

This function is performed in quadrupeds, cetaceous animals, and birds, absolutely in the same manner as in the human species. In fishes, the heart has but one ventricle, and the lungs, or gills, do not receive blood, by means of a peculiar cavity of the heart. Reptiles resemble fishes in this respect. The heart of insects and worms consists of a series of nodules, which contract one after the other ; their vessels are very small, and their blood cold and colourless. Polypi have neither heart nor vessels ; and are inferior to vegetables, with respect to this function ; for in them we find vessels, juice, and a kind of circulation of this fluid in trees and shrubs.

ARTICLE II.

Concerning Secretion.

Secretion is a function, by which different organs separate from the blood, juices destined to particular uses, as the bile in the liver, &c. This function is one of the most general in animals, and is found in all the classes ; but it is not possible to attend to it in each, without entering into too long a

detail. It will therefore be sufficient to observe, that in all animals, which have a true circulation, the secretions follow the same laws as in man; and that it even appears to take place in most animals which have not a heart. Besides the analogy that necessarily subsists between man and animals which have the same organs, with respect to the functions we are treating of, certain classes of animals exhibit peculiar secretions, which are not performed in the human species; such are the musk and civet in quadrupeds, spermaceti and amber-grise among cetaceous animals, the oily fluid, with which birds smear their wings, the virulent fluid of the viper, the adhesive fluid of the scales of fishes, the acrid and acid juices of the buprestis, staphylini, ants, and wasps, among insects; the viscous mucilage of snails, the colouring juices of the purple fish, or murex, and a great many others, which the natural history of each animal displays.

ARTICLE III.

Concerning Respiration.

Respiration, considered in all animals, is a function intended to bring the blood into contact with the fluid they inhabit: men and quadrupeds, for this purpose, have an organ called the lungs. This viscus consists of a collection of hollow vesicles, which are formed by the expansion of a membranous and cartilaginous tube, called the arteria trachea, and of blood-vessels, which form a great number of areolæ at the surface of the bronchial vessels: these vesicles and vessels are sustained by a cellular, loose, and spongy substance, which forms the parenchyma of the lungs. The air distends the vessels by inspiration; the oxygen of the atmosphere combines with the carbon disengaged from the blood, and forms the carbonic acid, which is expired, together with the azotic gas. A certain quantity of hydrogen is likewise disengaged from the venous blood, which, by uniting with the oxygen of the atmosphere, forms the water which is exhaled with the air. Another portion of water, proceeding directly from the pulmonary transpiration, is dissolved in the air that is ex-

pired. The caloric, or the matter of heat, being separated from the vital air, unites with the blood, and restores it to the temperature of 93 or 94 degrees. Thus the use of this function consists in the formation of the blood, in the production of its temperature, and in the destruction of several superfluous principles with which this liquid is loaded by the chyle, and in the course of circulation.

This function is performed in the same manner in cetaceous animals; excepting, however, that as there is an immediate communication between the auricles, these animals are capable of remaining a considerable time without respiring.

Though the respiration in birds be analogous to that of the animals last treated of, yet it appears to be much more extensive. Anatomists have discovered, in the abdomen of birds, spongy vesicular organs, which communicate with their lungs; and these last extend even into the bones of the wings, which are hollow, and without marrow, by a channel placed at the upper parts of the breast, and which opens in the superior part of the os humeri. This happy discovery of Mr. Camper teaches us, that the air passes from the lungs of birds into the bones of their wings; and that this fluid, rarified by the heat of their bodies, renders them very light, and singularly assists their flight. The extent of the pulmonary organ likewise accounts for the temperature of the blood of birds being higher than that of man, quadrupeds, or cetaceous animals. The motion of this fluid ought likewise to receive particular modifications from the same cause, upon which depends those differences that are found in their flesh, and all their solids.

Fishes have gills, or branchiæ, instead of lungs; these organs are formed of membranous fringes, disposed on a bony arch, and charged with a very great quantity of blood-vessels. The water enters by the mouth of fishes; passes through the fringes, which are by that means separated from each other: presses and agitates the blood, and passes out through apertures situated at the two lateral and posterior parts of the head, on which two moveable bony valves, called opercula, are placed, and sustained by the branchial membrane. Duverney supposed that the branchiæ separate the air contained in water. Vicq. d'Azir, who has paid great attention to the anatomy of

fishes, thinks that the water performs the office of air in the branchiæ of these animals. It is certain, that as fishes do not respire air, and convert it into carbonic acid, their blood does not possess the degree of heat, which the air gives to such animals as respire it; nor does it appear to be of the same nature with the blood of man, quadrupeds, or birds.

Insects have no lungs; they have two tubes, or tracheæ, placed along the back, from which, on each side, other smaller tubes issue forth, and terminate at the lateral part of each wing, by a small cleft, called *stigma*. These stigmata appear rather to be designed to emit some elastic fluid, since insects do not quickly die in a vacuum; though they have convulsions, and expire in a few instants, if the stigmata be covered with oil or varnish. Worms have an organization still less perfect. No kind of respiration has been observed in polypi, who, with respect to this function, are less perfect than vegetables, in which we have observed tracheæ.

ARTICLE IV.

Concerning Digestion.

Digestion consists in the separation of the nutritive matter contained in food, and its absorption, by peculiar vessels, called *chyliferous*. It is performed in a channel, which is continued from the mouth to the anus, and which, in man, is enlarged towards the upper part of the abdomen. This enlargement is called the stomach. The alimentary canal afterwards becomes narrower, is turned in different directions, and is distinguished by the name of the intestines. This long tube, which is formed of muscles and membranes, retains the aliments, so as to extract all the nutritive matter they contain. There are likewise other glandulous organs, near the stomach, whose office is to prepare the fluids requisite to stimulate the stomach and intestines, and to extract the nutritive part of the food; these organs are the liver, the spleen and the pancreas. The bile and pancreatic juice flow into the first intestine, called the duodenum, and mix with the food. Before this mixture is performed, the aliments are dissolved in the stomach, by the gastric juice.

The whole course of the intestines is covered with vascular apertures, destined to extract the chyle. These vessels convey it into the receptaculum lumbare, in the thoracic duct, and the chyle is poured into the left subclavian vein, in which it mixes with the blood. Such, in a few words, are the mechanism and phenomena of digestion in man.

Quadrupeds differ greatly in the form of their teeth, stomach and intestines: some of these animals, as the ant-eater, and the scaly lizard, which live on soft food, have no teeth; others, such as the sloth and the armadillo, have only grinders; others, as the elephant and sea cow, have molar and canine teeth; lastly, the greater number have the three kinds of teeth, molar, canine, incisive; but their number, position, and strength, are subject to great variations. The most striking circumstance in this various structure of the teeth, is, that according to the remark made by Aristotle, Galen, &c. there is a constant relation between the number and position of these bones, and the form of the stomach. In fact, all quadrupeds which have incisive teeth in both jaws, as the horse, the ape, the squirrel, the dog, the cat, have no more than one membranous ventricle, as in man; anatomists call these animals *monogastrica*; and in these the digestion is performed absolutely in the same manner as in the human species. Quadrupeds which have incisive teeth only in the inferior jaw, are *polygastrica*, and ruminating: such are the camel, the goat, the ram, the ox, the stag, &c. These quadrupeds, which are usually bisulc, and armed with horns, have four stomachs; the first, called in oxen the paunch, is the largest, and is divided into four other cavities; it receives the aliments at the same time with the second, which opens into the paunch by a large orifice. The herbaceous aliments, contained in these organs, dilate, and the air becomes rarified; the nerves of these viscera are stimulated, and an anti-peristaltic motion is excited, which returns them, through the œsophagus, into the mouth; where they are again masticated by the molar teeth, and reduced into a kind of soft paste. In this state, together with the drink, they are conducted, by a new deglutition, into the third stomach, called the *omasus*, by means of a duct passing from the œsophagus to this last ventricle. Lastly, They pass from the

omasus into the fourth stomach, where they are truly digested. The intestines of ruminating animals are likewise much more extended than those of monogastric quadrupeds. Cetaceous animals perfectly resemble these last, in the mechanism of the cow treated of last. Birds differ from each other in the structure of their stomach; in some it is membranous, and in others fleshy, or muscular. The first sort, which may be called *lynenogastrica*, are carnivorous; all birds of prey are of this species. Their stomach contains a very active juice, capable of softening bones, according to the experiments of Reaumur: their bile is likewise very acrid. The second, which may be called *myogastrica*, subsist only on grain; their stomach is formed of a quadrigastric muscle, armed with a hard and thick membrane, proper for trituration; these birds have likewise a double cœcum.

Fishes have a membranous long stomach, with many appendices; their intestines are in general short. Reptiles exhibit the same structure; their stomachs are capable of an astonishing degree of distention. Serpents are often seen to swallow entire animals, much larger than themselves.

Insects have a stomach and intestines, which are well organized. Swammerdam and Perrault affirm, that the mole-cricket has four stomachs. Their stomachs are divided into four cavities, as may be easily seen by dissecting this insect, which is very common, and much feared by gardeners. Worms have a very irregular stomach, and likewise small intestines. The polypus seems to be merely a stomach, for it digests very quickly: the same aperture serves this creature both as mouth and anus. In all animals the digestive organs afford a fluid for dissolving the aliments, and converting them into chyle. This function may be considered as a true animal solution.

ARTICLE V.

Concerning Nutrition.

Nutrition is a consequence of digestion and circulation. As the solids always lose, or become diminished, by the motions they perform, and require to be repaired, this is performed by

nutrition. In the early part of life, they increase in bulk, and the animal grows. The cellular membrane is usually considered as the organ of this function, and the lymph as the fluid proper to restore the solids. It appears, nevertheless, that each organ is nourished by a peculiar and proper matter, which it separates, either from the blood, the lymph, or some other fluid which passes through it. For example; the muscles are maintained by the fibrous matter, which they separate from the blood: the bones extract from the same fluid calcareous phosphat, and a gelatinous matter; the pure lymph dries in laminæ on the cellular texture; the concrescible oil being at the same time deposited for the production of fat. Each organ, therefore, is nourished in a peculiar manner, and in each, nutrition is a true secretion. The system of the absorbent vessels seems to contribute powerfully to the exercise of this function. Quadrupeds and cetaceous animals perfectly resemble man, with regard to this function. The same remark applies also to birds; but it is performed much less quickly with fishes; for which reason these animals live a very long time: the age of some of them is not known; but in general the slower the nutrition and the growth, the longer the life.

Insects exhibit nothing remarkable with regard to this function. It must only be observed, that they grow only in the form of larvæ, and not in that of the chrysalis, or of the perfect insect. Swammerdam and Malpighi have proved, that the larva contains a perfect insect, ready formed beneath a number of skins. The caterpillar likewise contains the butterfly, whose wings and feet are doubled up.

In worms and polypi, nutrition is performed in the cellular membrane, and is likewise performed in vegetables, by means of the reticular and vesicular membranes.

ARTICLE VI.

Concerning Generation.

Generation, considered in all animals, is performed in many different manners; most of them have different sexes, and re-

quire conjunction. Such are the human species, quadrupeds, and cetaceous animals. The females of quadrupeds have a matrix, separated into two cavities, *uterus bicornis*, and a considerable number of teats; they have not the menstrual flux; most of them bear several young at a time; the time of their gestation is shorter; several have a peculiar membrane to receive the urine of the foetus; this membrane is called allantoides.

The generation of birds is very different. The males have a very small and imperforated genital organ, which is often double. The vulva, in females, is placed behind the anus; the ovaria have no matrices; and there is a duct for the purpose of conveying the egg from the ovarium into the intestines; this passage has been called *oviductus*. The egg of pullets has exhibited unexpected facts to physiologists, who have examined the phenomena of incubation. The most important discoveries are those of Malpighi and Haller. The latter found the chicken, perfectly formed, in eggs which were not fecundated.

There is no determinate conjunction among fishes; the female deposits its eggs on the sand, over which the male passes, and emits its feminal fluid, doubtless for the purpose of fecundating them; these eggs are hatched after a certain time.

The males of several oviparous quadrupeds have a double, or forked organ. Among serpents, the viper is not viviparous.

Insects alone exhibit all the varieties which are observed in other animals. There are some, and indeed the greater number, which have the sexes in two separate individuals; among others, the re-production is made either with or without conjunction, as in the vine-fretter, Puceron; one of these insects, confined alone beneath a glass, produces a great number of others. Bonnet has established this fact, by experiments very carefully repeated. The organ of the male is enclosed in the abdomen, and may be caused to appear, by lightly pressing the extremity of this part. It is usually armed with two hooks, to seize the female. The place of these organs is greatly varied; with some it is at the upper part of the belly, near the breast-plate, as in the female of the dragon-fly; in others, it is at the extremity of the antenna, as in the male spider. In-

fects multiply prodigiously, and are almost oviparous, except the wood-louse.

Worms are hermaphrodites; each individual has two sexes, and the conjunction is double, as is observed in the earth-worm and the snail.

Mr. Adanson adds, that bivalves, shell animals, or concha, have no organs of generation, and reproduce their young without conjunction; these worms are viviparous. Univalves, or snails, are oviparous; the small animals, whether they issue from the belly of the mother, or from eggs, have their shell ready formed.

Polypi are the most singular animals, with respect to generation; they are reproduced by buds, or offsets: a bud is separated from each vigorous polypus, which is fixed to some neighbouring body, and grows: polypi are likewise found on their surface, in the same manner as branches issue from the trunks of trees.

The mere phenomena of generation compose the whole of our knowledge of the subject; and all the systems invented to explain this mystery are attended with insurmountable difficulties; they may be seen collected in the *Physiology of Haller*, the *Venus Physique* of Maupertuis, and the *Natural History of Buffon*. Bonnet has treated largely on this subject, in his *Considerations on Organized Bodies*. Buffon has given an ingenious system, which may be seen in his work. Through the whole animal kingdom, the eggs seem to pre-exist in the female; and the fecundating liquor of the male, only appears to communicate the first movement to the heart. So active is the fecundating power of this fluid, that when diluted with a large quantity of water, it still retains this property, as is observable in the frog.

ARTICLE VII.

Concerning Irritability.

Irritability is the property which certain organs, called muscles, possess of contracting or shortening by the action of any stimulus which touches them. Mr. Haller has proved

this valuable doctrine in the most perspicuous manner. The muscles of man, of quadrupeds, of cetaceous animals, and of birds, resemble each other ; they are all alike red, composed of fibres, united in bundles of different forms, covered with silver-coloured membranes, called aponeuroses, and terminated by flat, or round cords, named tendons.

The muscles of fishes are white, and much more irritable than those which are red. The irritability in oviparous quadrupeds and serpents is still stronger, and lasts a long time after the death of the animal. This appears to be a common property in all animals whose blood is cold ; whereas, in animals which have warm blood, it disappears in proportion as that fluid cools.

Insects have their muscles placed within their bones, which are hollow, and of the nature of horn. This structure may be well observed in the hollow thigh of the large green grasshopper, and may likewise be easily observed in the lobster.

The muscles of worms are very pale and irritable ; they are likewise very strong in covered worms, which have a heavy shell to carry.

Polypi are very irritable ; they contract into a single point, and move their arms with singular agility ; yet their structure does not appear to be muscular.

It is from the property of irritability that animals possess the power of transporting themselves from place to place, and of performing a great number of motions, to remove noxious things, and to obtain those which are useful. The history of this function ought, therefore, to include that of animal motions. Standing, walking, leaping, flying, creeping, or swimming, are combined actions, or the results of muscular contractions, in each class of animals. An explanation of these, would require a description of the extensor muscles of the thigh of man, for standing ; that of the extremities of the figure of the body ; the long and acute face, and the thorax, laterally compressed, in quadrupeds, for leaping ; of the structure of the feathers, the sternum, the pectoral muscles, the beak, the tail, and the interior texture of the bones, of birds, for flying. In this history, likewise, it would be necessary to consider at large, the muscular annuli, the scales, or the tuber-

cles, which answer the purpose of feet in reptiles ; the form of the body, the structure of the fins, of the air-bladder, and its communication with the stomach, in fishes ; and in insects, the structure, number, and position of the feet, the appendices of the tarsus, the form, position, and nature of the wings, the balancers, &c. But it is sufficient, in this place, to have shown the importance of these considerations, and such as peculiarly deserve the attention of the physiologist.

Lastly, There is another consideration, which does not appear to have been sufficiently attended to ; namely, that a muscle may be regarded as a secretory organ appropriated to the separation of the fibrous and irritable matter, of which we have elsewhere spoken ; and that the imperfections of this kind of secretion ought to be very carefully observed by physicians. We have already treated of this object in our account of the blood ; it may be seen detailed in a memoir, inserted among those of the Society of Medicine.

ARTICLE VIII.

Concerning Sensibility.

Sensibility is a function, by means of which animals experience the sensations of pleasure and pain, according to the nature of the bodies which are in contact with their organs. The senses depend on the brain, the medulla allongata, the spinal marrow, and the pairs of nerves, which issue in great numbers from these three foci ; without these organs, sensibility could not exist. In order to understand the mechanism of this function more readily, we may divide into three regions, those organs which are continued, and seem to form but one, which some physiologists have called the sensible man : these three regions consist of the brain, the cerebellum, and the medulla allongata ; the middle or part of communication consists of the nervous fibres, and the sensitive expansion, or dilated extremity, of the nerves. This extremity exhibits various forms in different organs ; in some it is membranous and reticular, as in the stomach and intestines ; in others, it is soft and pulpy, as at the bottom of the eye, and in the labyrinth of the internal ear :

in some situations, it has the form of papillæ, as beneath the skin, on the tongue, and on the glands, &c. ; and in others it is spread into long, soft, and flat fibres, as in the membrane of Schneider.

The brain in man is larger and better organized than in other animals, and is the cause of his understanding. In quadrupeds it is much smaller ; but on the other hand, their nerves are more sensible, and their senses more acute, especially that of smell, the organ of which is much dilated, and as it were multiplied, by the number of ethmoidal laminæ. Their thick hairy skin deprives them, in a great measure, of the sense of touch ; but their taste is very acute. The ear has the same apparatus, as in man.

Cetaceous fish have scarcely any brain, in proportion to the mass of their bodies ; this organ is surrounded with an oily and thick fluid ; their senses are obtuse.

The brain of birds has neither the same structure nor the same apparatus of folds, eminences, and concavities, as that of man and quadrupeds. The beautiful structure of the eyes of these animals, their magnitude, and thick and cartilaginous sclerotica, the internal eye-lid, or *membrana nictitans*, moved by peculiar muscles, the mass of the crystalline and vitreous humours, the vessel of black matter contained at the extremity of the optic nerve, the brilliant colour of the choroides, all denote a complicated organization, and a peculiar care taken by nature to render the sight of birds penetrating ; that they may see their prey at a great distance, and avoid the dangers which the rapidity of their flight would otherwise have continually led them into ; and, in a word, to promote that agility and quickness of motion, which appear to be the lot of these animals. Their smell is less perfect than their sight ; they do not appear to be very sensible of the smell and taste of food ; the situation of the apertures of the nostrils, and the hard membrane which covers the beak, serve to explain these phenomena with sufficient facility.

Among oviparous quadrupeds and serpents, the sensibility is not very considerable. The brain is very small, and the nerves have no ganglions ; the senses, in general, do not appear to be active, though the eye, and internal ear, presented a very

beautiful organization to Messrs. Klein, Geoffroy, and Vicq d'Azyr.

Fishes have a very small brain, and their cranium is filled with an oily matter. Their senses, more especially their sight and hearing, are of considerable delicacy. The organ for the latter of these senses is very well formed, as Messrs. Klein, Geoffroy, Camper, and Vicq d'Azyr have observed. Such naturalists as have supposed fishes to be deaf, appear therefore to be mistaken.

Insects have no brain, but a lengthened medullary substance, of a cylindric form, full of nodules, which occupy the whole length of their body. From this substance issue nervous fibres, which accompany the division of the trachea. The eyes of insects are known. Swammerdam has described an optic nerve, which is divided in such eyes as have the appearance of net-work, into as many fibres as there are facets in that membrane. It is not known whether they have an organ of hearing.

Few or no traces of the sensible organ are perceived in worms. Swammerdam found in the snail a brain moveable and with two lobes, eyes placed either on the base or at the point of the tentacula, and an optic nerve, contractable like those kind of horns. Mr. Adanson affirms, that eyes are sometimes either wanting in worms, or that they are covered with an opaque skin.

As to polypi, they have no organ of sense, though they appear to seek the light.

Sensibility is therefore a function enjoyed by man in a much stronger degree than by other animals. It is this which distinguishes him, and places him at the head of the animated creation; and this function requires to be carefully and minutely inquired into, by the legislator, the philosopher, and the physician.

SUPPLEMENT

TO THE

MINERAL KINGDOM.

OF THE NATURE OF MINERAL WATERS, AND THE METHODS OF
ANALYSING THEM.

AFTER having considered all the bodies belonging to the mineral kingdom, and examined their physical properties, it seems proper to introduce, in this place, the history of mineral waters; for, as these fluids generally hold, in solution, terrene, saline, and metallic matters, either together or separately, it would have been impossible to make the reader understand their nature and composition, without making him previously acquainted with the nature of the principles by which they are mineralized. Another advantage arising from our introducing, in this place, the account of mineral waters, is, that it may here serve as a sort of recapitulation of what has been said of minerals in general; as their principles must be taken notice of, in considering the manner of analysing them.

§ I. *Definition and History of Mineral Waters.*

Waters holding minerals in solution, are called *mineral waters*. But as all water, in a natural state, is impregnated, either more or less, with some mineral substances, the name, *mineral waters*, should be confined to such waters as are sufficiently impregnated with mineral matters, to produce some sensible effects on the animal economy, and either to cure or pre-

vent some of the diseases to which the human body is liable *. On this account, these waters might be, with much more propriety, called *médicinal waters*,—were not the name by which they are commonly known too firmly established by long use.

The first knowledge of mineral waters, like every other branch of knowledge we possess, was accidentally discovered. The good effects they produced on such as used them, have doubtless been the cause of distinguishing them from common waters. The first philosophers who considered their properties, attended only to their sensible qualities, such as colour, weight, or lightness, smell, and taste. Pliny, however, distinguished a great number of waters, either by their physical properties, or their uses; but the inquiry after methods of ascertaining, by chemical processes, the quantity and quality of the principles held in solution by mineral waters, was not attempted till the seventeenth century. Boyle is one of the first, who, in the valuable *Experiments on Colours*, published by him at Oxford in 1663, mentioned several re-agents capable of indicating the substances dissolved in water, by the alteration produced in their colours. The academy of sciences, from its first institution, was aware of the importance of analysing mineral waters; and Duclos, in 1667, attempted the examination of the mineral waters of France: the researches of this chemist may be found in the original *Memoirs* of this Society. Boyle was particularly employed in inquiries respecting mineral waters about the end of the seventeenth century, and published a treatise on this subject in 1685. Boulduc, in the year 1729, published a method of analysing waters, which is much more perfect than any which were employed before his time: it consists in evaporating these fluids, at different times, and separating, by filtration, the substances which are deposited, in proportion as the evaporation proceeds.

Many celebrated chemists have since made successful experi-

* It is to be observed, that though waters contain no mineral principles which can be discovered by analysis, they may yet produce sensible effects on the animal economy. For this purpose, they need only to be very light and active, and of an hotter temperature than common water. Such are the waters of Plombieres and Luxeuil, which differ only in temperature from common water.

ments on mineral waters, and almost every one made valuable discoveries respecting the different principles contained in these fluids. Boulduc discovered natrum, and determined its properties; Le Roi, physician of Montpellier, discovered calcareous muriat; Margraaff the muriat of magnesia; Priestley carbonic acid; and Monnet and Bergman the sulphurated, or *hepatic* hydrogen gas. The two last-mentioned chemists, besides the discoveries with which they have enriched the art of analysing waters, have published complete treatises on the method of proceeding in this analysis; and have carried this part of chemistry to a degree of perfection and accuracy, far exceeding that which it possessed before the time of their labours. We are likewise in possession of particular analyses, made by very good chemists, of a great number of mineral waters, and which serve to throw great light on this inquiry, which, with justice, is esteemed one of the most difficult in the whole art of chemistry. The limits we have prescribed to ourselves do not permit us to enter at large into the history of the analysis of waters, which may be found in many treatises; but we shall not fail to mention the authors of discoveries as occasion may require.

§ II. *Principles contained in Mineral Waters.*

It is but a few years since the substances capable of remaining in solution in water have been accurately known. This appears to have arisen from the want of accurate chemical methods of ascertaining the nature of these substances; and the certainty of their existence has naturally followed the discovery of methods of ascertaining them. Another cause which has retarded the progress of science in this respect, is, that mineral matters, dissolved in waters, are almost always in very small doses, and are also mixed together in considerable numbers, so that they mutually tend to conceal or alter those properties in which their distinctive characters consist. Nevertheless, the numerous experiments of the chemists we have quoted, and a great number of others, which we shall occasionally mention, have shown, that some mineral substances are often found in waters, others scarcely ever met with; and lastly,

many which are never held in solution by that fluid. We shall here consider each class of these substances in order.

Siliceous earth is sometimes suspended in waters; and as it is in a state of extreme division, it remains suspended without precipitating; but its quantity is extremely minute. The carbonated alkalis and chalk probably contribute to render siliceous earth soluble.

Alumine likewise appears to exist in water: the extreme subtlety of this earth, by which it is dispersed through the whole mass of water, causes it to render them turbid. Argillaceous waters are therefore whitish, and have a pearl, or opal colour; they are likewise smooth, or greasy to the touch, and have been called saponaceous waters. Carbonic acid seems favourable to the suspension and solution of alumine in water.

Lime, magnesia, and barytes, are never found pure in waters; they are always combined with acids.

Fixed alkalis are never met with in a state of purity in waters, but frequently combined with acids, in the form of neutral salts.

The same observation applies to ammoniac, and most acids, except the carbonic acid, which is often free, and in possession of all its properties in waters. It constitutes a peculiar class of mineral waters, known by the name of *gaseous*, *spirituous*, or *acidulous* waters.

Among the neutral salts, with bases of fixed alkalis, scarcely any are met with but sulphat of soda or *Glauber's salt*, the muriats of soda, and of potash, and carbonat of soda, which are frequently dissolved in mineral waters; nitrat and carbonat of potash, are rarely found.

Sulphat of lime, calcareous muriat, chalk, sulphat of magnesia, or *Epsom salt*, muriat of magnesia, and carbonat of magnesia, are the earthy salts which are most commonly found in waters. As to the calcareous nitrat, and nitrat of magnesia, which some chemists have asserted they have met with, these salts are scarcely ever found in mineral waters, properly so called, though they exist in salt waters.

The aluminous neutral salts, and salts with base of barytes,

are scarcely ever dissolved in waters. Alum or acid sulphat of alumine, appears to exist in some waters*.

Pure hydrogen gas has not yet been found dissolved in mineral waters.

Pure sulphur has not yet been found in these fluids, though it exists very rarely, in small quantities, in the state of sulphure of soda. Sulphureous waters are most commonly mineralized by sulphurated hydrogen gas.

Lastly, Among metals, iron is most commonly dissolved in waters, and may be found in two states; either combined with carbonic acid, or with the sulphuric acid. Some chemists have supposed that it was likewise dissolved in its metallic state, without an acid intermedium; but as this metal scarcely ever exists in nature, without being in the state of oxyd, combined with the carbonic or sulphuric acid, the opinion of these philosophers could only be maintained at the time when the carbonic acid was not yet discovered: and the solution of iron in water, without the assistance of the sulphuric acid, could not otherwise be accounted for. Bergman affirms, that iron, as well as manganese, is found in certain waters, combined with the muriatic acid.

Oxyd of arsenic, and the sulphats of copper and zinc, which exist in many waters, communicate poisonous properties to them, and show, when discovered by analysis, that the use of such waters must be carefully avoided.

Most chemists, at present, deny the existence of bitumen in waters: in fact, the bitter taste was the cause why waters were formerly supposed to contain this oily substance; but it is now known that this taste, which does not exist in bitumen, is produced by the calcareous muriat.

There is no difficulty in conceiving how water, which percolates through the interior parts of the globe, and especially through the mountains, may become charged with the different substances we have enumerated. It is likewise clear, that,

* We do not here mention the opinion of Le Givre, and other chemists, who consider alum as one of the most usual principles found in mineral waters. But accurate experiments, made by Mitouart, have shown, that the waters of La Dominique de Vals contain alum; and Opoix has ascertained the existence of this salt in the waters of Provins.—*Note of the Author.*

according to the nature and extent of the strata of earth, through which they pass, mineral waters will be more or less charged with these principles, and that the quantity and nature of these principles must be subject to great variations, especially when we consider the changes in the direction of their course to which these fluids are liable from the various alterations which the globe undergoes, particularly on its surface and its more elevated parts.

§ III. *The different Classes of Mineral Waters.*

It appears from what we have already observed respecting the different substances usually contained in mineral waters, that these fluids may be classed according to the earthy, saline, and metallic substances they hold in solution; and that the number of classes, on this principle, would be very considerable: but it must be observed, that none of these substances are found single and alone in waters; but, on the contrary, they are often dissolved, in the number of three, four, five, or even more. This circumstance creates a difficulty in the methodical classification of waters, relative to the principles that they contain. However, if we attend to those substances which are the most abundantly contained in waters, or whose properties are the most prevalent, we shall be able to make a distinction, which, though not very accurate, will be sufficient to arrange these fluids, and to form a judgment of their virtues. Chemists, who have attended to mineral waters in general, have availed themselves of this method. Monnet has established three classes of mineral waters; the alkaline, the sulphureous, and the ferruginous; and subsequent discoveries have enlarged the number of classes. Duchanoy, who has published a valuable treatise on the art of imitating mineral waters, distinguishes ten, viz. the gaseous, the alkaline, the earthy, the ferruginous, the simple hot, the gaseous thermal, the saponaceous, the sulphureous, the bituminous, and the saline waters. Although it may be urged as a reproach, that this author has made his classes too numerous, since the pure gaseous and bituminous waters are unknown; yet his division is doubtless the most complete, and gives the most accurate idea of the nature of the different mineral waters, and consequently is the

best suited to his subject. We shall here propose a division less extensive, and in our opinion more methodical, than that of Duchanoy; at the same time observing, that we do not consider simple thermal waters as mineral waters, because they consist merely of heated water, according to the best chemists; and that we shall not speak of bituminous waters, because none such have been yet found.

It appears to us, that all mineral waters may be arranged in four classes, viz. acidulous, saline, sulphureous, and ferruginous waters.

CLASS I. *Acidulous Waters.*

Gaseous waters, which may with more propriety be called acidulous waters, are those in which the carbonic acid predominates; they are known by their sharp taste, and the facility with which they boil, and afford bubbles by simple agitation: they redden the tincture of turnsole, precipitate lime water and alkaline sulphures. As no waters have yet been discovered which contain this acid pure and alone, we think this class may be divided into several orders, according to the other principles contained in them, or the modifications they exhibit. They all appear to contain more or less alkali and calcareous earth; but their different degrees of heat afford a good criterion for dividing them into two orders; the first might comprehend cold, acidulous, and alkaline waters, such as those of Seltzer, Saint-Myon, Bard, Langeac, Chateldon, Vals, &c.; in the second might be placed, hot, or thermal, acidulous, and alkaline waters, as those of Mount D'Or, Vichy, Chatelguyon, &c.

CLASS II. *Saline or Salt Waters.*

By the name of saline waters, we understand such as contain a sufficient quantity of neutral salt to act strongly on the animal economy, so as most commonly to purge. The theory and nature of these waters are easily discovered; they perfectly resemble the solutions of salts made in our laboratories; but they almost always contain two or three different species of salts. The sulphat of soda is very rare; sulphat of magnesia, or Epsom salt, marine salt, or muriat of soda, calcareous

and magnesian muriats, are the saline principles which mineralize them, either together or separate. The waters of Sedlitz, of Seydschutz, and of Egra, abound with Epsom salt, frequently mixed with muriat of magnesia. Those of Balaruc contain muriat of soda, chalk, and the calcareous and magnesian muriats; those of Bourbonne, muriat of soda, fulphat of lime, and chalk; and those of la Mothe contain muriat of soda, fulphat of lime, chalk, fulphat of magnesia, muriat of magnesia, and an extractive matter. It must be here observed, that salts, with base of magnesia, are much more common in waters than has hitherto been supposed; and that few analysis have yet been made, in which they have been well distinguished from calcareous muriat.

CLASS III. *Sulphureous Waters.*

The name of sulphureous waters has been given to such mineral waters as appear to possess some of the properties of sulphur; such as the smell, and the property of discolouring silver. Chemists have long been ignorant of the true mineralizer of these waters; most have supposed it to be sulphur, but they never succeeded in exhibiting it, or at least have found it in quantities scarcely perceptible. Those who have made experiments on some of these waters have allowed them to contain either sulphureous spirit, or an alkaline sulphure. Venel and Monnet are the first who opposed this opinion; the latter, in particular, nearly discovered the truth, when he considered sulphureous waters as impregnated merely by the vapour of *liver of sulphur*. Rouelle the younger likewise affirmed, that these fluids might be imitated by agitating water in contact with *air*, disengaged from an alkaline sulphure by an acid. Bergman carried this doctrine much farther, by examining the properties of sulphurated hydrogen gas, which we have spoken of under the article Sulphur: he has proved that this gas mineralizes sulphureous waters, which he therefore calls *hepatic waters*, and has directed methods of ascertaining the presence of sulphur. Notwithstanding these discoveries, Duchanoy, speaking of sulphureous waters, admits of sulphure, sometimes alkaline, sometimes calcareous, or aluminous. He follows the opinion of Le Roy of Montpellier, who, as we have

observed in the History of Sulphur, proposed a sulphure with base of magnesia in imitating these waters. It appears in fact to be true, that there are waters which contain a small quantity of sulphure, while there are others which are mineralized only by sulphurated hydrogen gas. In this case it will be necessary to distinguish sulphureous waters into two orders: 1. Those which contain a small quantity of alkaline or calcareous sulphure; and, 2. Those which are only impregnated with sulphuric hydrogen gas. The waters of Baresges and Cautejets, and the Bonnes waters, appear to belong to this first order; and those of St. Amant, Aix la Chapelle, and Montmorency, appear to belong to the second. Most of these waters are thermal, but that of Montmorency is cold.

CLASS IV. *Ferruginous Waters.*

Iron being the most abundant of metals, and the most susceptible of alteration, it is not to be wondered at that water easily becomes charged with it, and consequently that the ferruginous waters are the most abundant and most common of all mineral waters. Modern chemistry has thrown great light on this class of waters; they were formerly supposed to be all impregnated with sulphat of iron. Monnet has ascertained that most of them do not contain this salt, and he supposed that the iron is dissolved without the intermedium of an acid. It is at present known, that the iron is not in the state of sulphat, but is dissolved by means of the carbonic acid, and forms the salt which we have called Carbonat of Iron. Lane, Rouelle, Bergman, and many other chemists, have put this out of doubt. The greater or less quantity of carbonic acid, and the state of the iron in waters of this kind, render it necessary to distinguish the present class into three orders.

The first order comprehends martial acidulous waters, in which the iron is held in solution by the carbonic acid, whose superabundance renders them brisk and subacid. The waters of Bussang, Spa, Pyrmont, Pouhon, and La Dominique de Vals, are of this first order.

The second contains simple martial waters, in which the iron is dissolved by the carbonic acid, without excess of the latter. These waters consequently are not acidulous. The water of

Forges, Aumale, and Conde, as well as the greater number of ferruginous waters, are of this order; this distinction of ferruginous waters was made by Duchanoy.

But we add a third order, after Monnet, which is that of waters containing sulphat of iron. Though these are extremely rare, yet some of them are found. Monnet has placed the waters of Passy in this order. Opoix admits the sulphat of iron, even in a considerable quantity, in the waters of Provins. It is true, that De Fourcy denies its existence, and considers the iron of these waters as dissolved by carbonic acid. But no decision can be made respecting this subject, because the results of these chemists entirely disagree, and require new experiments to be made. It must be added, that the iron is not found alone in these waters, but is mixed with chalk, sulphat of lime, various muriatic salts, &c. However, as the metal they contain is the principal basis of their properties, they must be called ferruginous, in conformity with the principles we have laid down*.

As to the saponaceous waters admitted by Duchanoy, we must wait till chemical and medical experiments have ascertained the cause of their saponaceous property, which this physician attributes to alumine; as well as of the effects they may produce in the animal economy, as medicines, by virtue of this property.

From these details we find, that all mineral and medicinal waters are divided into nine orders, viz.

Cold acidulous waters.

Hot or thermal acidulous waters.

Sulphuric saline waters.

Muriatic saline waters.

Simple sulphureous waters.

Sulphurated gaseous waters.

Simple ferruginous waters.

* In the enumeration of waters divided into classes, we do not mention those which may contain arsenic and copper, because they are true poisons. We likewise omit such waters as contain ammoniacal salts, and extractive matters produced by the putrefaction of organic matters on which they have stood. These waters are not medicinal.

Ferruginous and acidulous waters.

Sulphuric ferruginous waters.

§ IV. *Examination of Mineral Waters, according to their Physical Properties.*

After having shown the different matters which may be found in waters, and exhibited a slight sketch of the method in which they may be divided into classes and orders, according to their principles, it will be necessary to mention the methods of analysing them, and discovering with the greatest possible degree of accuracy, the substances they hold in solution. This analysis has been justly considered as the most difficult part of chemistry, since it requires a perfect knowledge of all chemical phenomena, joined to the habit of making experiments. To obtain an accurate knowledge of the nature of any water proposed to be examined, 1. The situation of the spring, and the nature of the soil, more especially with respect to mineral strata, must be carefully observed; for this purpose cavities may be dug to different depths, in order to discover, by inspection, the substances with which the water may be charged. 2. The physical properties of the water itself, such as its taste, smell, colour, transparence, weight, and temperature, must next be examined; for this purpose, two thermometers, which perfectly agree, and a good hydrometer, must be provided. These preliminary experiments require likewise to be made in the different seasons, different times of the day, and especially in different states of the atmosphere; for a continuance of dry weather, or of abundant rain, has a singular influence on waters. These first trials usually show the class to which the water under examination may be referred, and direct the method of analysis. 3. The depositions formed at the bottom of the basins, the substances which float on the water, and the matters which rise by sublimation, form likewise an object of important research, which must not be neglected. After this preliminary examination, the proper analysis may be proceeded on, which is made after three methods, by re-agents, by distillation, and by evaporation.

§ V. The Examination of Mineral Waters by Re-agents.

These substances, which are mixed with waters, in order to discover the nature of the bodies held in solution by such waters, from the phenomena they present, are called re-agents.

The best chemists have always considered the use of re-agents as a very uncertain method of discovering the principles of mineral waters. This opinion is founded on the considerations that their effects do not determine in an accurate manner, the nature of the substances held in solution in waters; that the cause of the changes which happen in fluids by their addition is often unknown: and that in fact, the saline matters usually applied in this analysis, are capable of producing a great number of phenomena, respecting which it is often difficult to form any decision. For these reasons, most chemists, who have undertaken this analysis, have placed little dependence on the application of re-agents. They have concluded, that evaporation affords a much surer method of ascertaining the nature and quantity of the principles of mineral waters; and it is taken for granted, in the best works on the analysis of these fluids, that re-agents are only to be used as secondary means, which at most serve to indicate or afford a probable guess of the nature of the principles contained in waters; and for this reason, modern analysts have admitted no more than a certain number of re-agents, and have greatly diminished the list of those used by the earlier chemists.

But it cannot be doubted at present, that the heat required to evaporate the water, however gentle it may be, must produce sensible alterations in its principles, and change them in such a manner, as that their residues, examined by the different methods of chemistry, shall afford compounds differing from those which were originally held in solution in the water. The loss of the gaseous substances, which frequently are the principal agents in mineral waters, singularly changes their nature, and besides causing a precipitation of many substances, which owe their solubility to the presence of these volatile matters, likewise produces a re-action among the other fixed matters, whose properties are accordingly changed. The phenomena of double decompositions, which heat is capable of

producing between compounds that remain unchanged in cold water, cannot be estimated and allowed for, but in consequence of a long series of experiments not yet made. Without entering, therefore, more fully into these considerations, it will be enough to observe, that this assertion, whose truth is admitted by every chemist, sufficiently shows, that evaporation is not entirely to be depended on. Hence it becomes a question, whether there be any method of ascertaining the peculiar nature of substances dissolved in water without having recourse to heat; and whether the accurate results of the numerous experiments of modern writers afford any process for correcting the error which might arise from evaporation. The following pages, extracted from a memoir communicated by myself to the Royal Society of Medicine, will show, that very pure re-agents used in a peculiar manner, may be of much greater use in the analysis of mineral waters than has hitherto been thought.

Among the considerable number of re-agents proposed for the analysis of mineral waters, those which promise the most useful results are tincture of turnsole, syrop of violets, lime-water, pure and caustic potash, caustic ammoniac, concentrated sulphuric acid, nitrous acid, prussiat of lime, gallic alcohol, or *spirituous tincture of nut-galls*, the nitric solutions of mercury and of silver, paper coloured by the aqueous tincture of fernambouc, which becomes blue by means of alkalis, the aqueous tincture of *terra merita*, which the same salts convert to a brown red, the oxalic acid to exhibit the smallest quantity of lime, and the muriat of barytes to ascertain the smallest possible quantity of sulphuric acid.

The effects and use of these principal re-agents have been explained by all chemists, but they have not insisted on the necessity of their state of purity. Before they are employed, it is of the utmost importance perfectly to ascertain their nature, in order to avoid fallacious effects. Bergman has treated very amply of the alterations they are capable of producing. This celebrated chemist affirms, that paper coloured with the tincture of turnsole becomes of a deeper blue by alkalis; but that it is not altered by the carbonic acid. But as this colouring matter is useful chiefly to ascertain the presence of this acid, he directs its tincture in water to be used, sufficiently diluted,

till it has a blue colour. He absolutely rejects syrup of violets, because it is subject to ferment. and because it is scarcely ever obtained without adulteration in Sweden Morveau adds in a note, that it is easy to distinguish a syrup coloured by turnsole, by the application of corrosive sublimate, which gives it a red colour, while it converts the true syrup of violets to a green.

Lime water is one of the most useful agents in the analysis of mineral waters, though few chemists have expressly mentioned it in their works. This fluid decomposes metallic salts, especially sulphat of iron, whose metallic oxyd it precipitates; it separates alumine and magnesia from the sulphuric and muriatic acids, to which these substances are frequently united in waters. It likewise indicates the presence of carbonic acid, by its precipitation. M. Gioanetti, a physician of Turin, has very ingeniously applied it to ascertain the quantity of carbonic acid contained in the water of St. Vincent. This chemist, after having observed that the volume or bulk of this acid, from which its quantity has always been estimated, must vary, according to the temperature of the atmosphere, mixed nine parts of lime water with two parts of the water of St. Vincent; he weighed the *calcareous earth* formed by the combination of the carbonic acid of the mineral water with lime, and found, according to the calculation of Jaquin, who proves the existence of thirteen ounces of this acid in thirty-two ounces of chalk, that the water of St. Vincent contained somewhat more than fifteen grains. But as the lime water may seize the carbonic acid united with fixed alkali, as well as that which is at liberty, M. Gioanetti, to ascertain more exactly the quantity of this last, made the same experiment with water deprived of its disengaged acid by ebullition. This process may therefore be employed to determine, in an easy and accurate manner, the weight of disengaged carbonic acid, contained in a gaseous mineral water.

One of the principal reasons which have induced chemists to consider the action of re-agents in the analysis of mineral waters as very fallacious, is, that they are capable of indicating several different substances held in solution in waters, and that it is then very difficult to know exactly the effects they will

produce. This observation relates more especially to potash, considered as a re-agent, because it decomposes all the salts which are formed by the union of acids with alumine, magnesia, lime, and metals. When this alkali precipitates a mineral water, it cannot, therefore, be known by simple inspection of the precipitate, of what nature the earthy salt, decomposed in the experiment, may be. Its effect is still more uncertain, when the alkali made use of is saturated with carbonic acid, as is most commonly the case, since the acid to which it is united augments the confusion of effects: for this reason, I propose the use of very pure caustic potash, which likewise possesses an advantage over the effervescent alkali, viz. that of indicating the presence of chalk dissolved in a gaseous water, by virtue of the superabundant carbonic acid; for it seizes this acid, and the chalk falls down of course. I have established this fact, by pouring soap lees newly made, into an artificial gaseous water, which held chalk in solution. The latter substance is precipitated in proportion as the caustic fixed alkali seizes the carbonic acid which held it in solution. By evaporating the filtrated water to dryness, I have obtained carbonat of soda, strongly effervescent with acids. The caustic fixed alkali likewise occasions a precipitate in mineral waters, though they may not contain earthy salts; for if they contain an alkaline neutral salt, of a less soluble nature, the additional alkali will precipitate it by uniting with the water, nearly in the same manner as alcohol does. M. Gioanetti has observed this phenomenon in the waters of St. Vincent; and it may easily be seen by pouring caustic alkali into a solution of sulphat of potash, or muriat of soda; these two salts being quickly precipitated.

Caustic ammoniac is in general less productive of error when mixed with mineral waters; because it decomposes only salts, with base of alumine or magnesia, and does not precipitate the calcareous salts. It is necessary, however, to make two observations respecting this salt: the first is, that it must be exceedingly caustic, or totally deprived of carbonic acid; without this precaution, it decomposes calcareous salts by double affinity: the second is, that the mixture must not be left exposed to air, when the effect of its action is required to be

inspected several hours after it is added ; because, as M. Giannetti has well observed, this salt in a very short time seizes the carbonic acid of the atmosphere, and becomes capable of decomposing calcareous salts. To put this important fact out of doubt, I made three decisive experiments ; some grains of sulphat of lime, formed of transparent calcareous spar, because chalk, or Spanish white, contain magnesia and river water. I divided this solution into two parts ; into the first I poured a few drops of very pure sulphuric acid, recently made, and very caustic ; this I put into a well-closed bottle : at the end of twenty-four and forty-eight hours it was clear and transparent, without any precipitate, and therefore no decomposition had taken place. The second portion was treated in the same manner with ammoniac, but placed in a vessel which communicated with the air by a large aperture : at the end of a few hours a cloud was formed near the upper surface, which continually increased, and was at last precipitated to the bottom. This deposition effervesced strongly with sulphuric acid, and formed sulphat of lime. The carbonic acid contained in this precipitate was therefore afforded by the ammoniac which had attracted it from the atmosphere. This combination of carbonic acid and ammoniac forms ammoniacal carbonat, capable of decomposing calcareous salts by double affinity, as Black, Jaquin, and many other chemists have shown, and as may be easily proved, by pouring a solution of ammoniacal carbonat into a solution of sulphat of lime, which is not rendered turbid by caustic ammoniac. Lastly, To render the theory of this second experiment clearer, I took the first portion to which the caustic ammoniac had been added, and which, having been kept in a close vessel, had lost no part of its transparency. I reversed the bottle which contained it, over the funnel of a very small pneumato-chemical apparatus, and by the assistance of a syphon, I passed into it carbonic acid gas, disengaged from the effervescent fixed alkali by sulphuric acid. In proportion as the bubbles of this acid passed through the mixture, it became turbid in the same manner as lime water : by filtration a precipitate was separated, which was found to be chalk, and the water, by evaporation, afforded ammoniacal sulphat : gaseous water, or the liquid carbonic acid, produced the same de-

composition in another mixture of sulphat of lime, and caustic ammoniac. This decisive experiment clearly shows, that ammoniac decomposes sulphat of lime by double affinity, and by means of the carbonic acid. Hence we see, that when it is required to preserve a mixture of the mineral water with ammoniac for several hours (which is sometimes necessary, because it does not decompose certain earthy salts, but very slowly), the experiment must be made in a vessel which can be accurately closed, in order to prevent the contact of air, which would falsify the result. This precaution, which is of great importance in the use of all re-agents, is likewise mentioned by Bergman and Gioanetti. To these I shall add another observation concerning the use of ammoniac: As it is a matter of considerable difficulty to preserve ammoniac in the state of perfect causticity, though it is necessary to be had in such a state, for the analysis of mineral waters, a very simple expedient, which I have often used with success, may be applied in this case. It is to pour a small quantity of ammoniac into a retort, whose neck is plunged in the mineral water: when the retort is slightly heated, the ammoniacal gas becomes disengaged, and passes highly caustic into the water. If it occasions a precipitate, it may be concluded that the mineral water contains sulphat of iron, which may be known by the colour of the precipitate, or otherwise that it contains salts, with base of aluminous or magnesian earth. Generally this precipitate is formed by the chalk which was held in solution in the water, by means of the carbonic acid; ammoniac absorbs this acid, and the chalk is deposited. It is difficult to determine from the physical properties of the earthy precipitate formed in waters by caustic ammoniac, to which of the two last bases it is to be attributed; yet the manner in which it is formed may serve to decide. Six grains of sulphat of magnesia were dissolved in four ounces of distilled water, and six grains of alum in an equal quantity of the same fluid: through each of these solutions a small quantity of ammoniacal gas was passed: the first solution immediately became turbid, while the latter did not begin to exhibit a precipitate till twenty minutes after. These mixtures were carefully included in well-closed bottles. The same phenomenon took place with the nitrats and muriats

of magnesia and alumine, dissolved in equal quantities of distilled water, and treated in the same manner. The quickness or slowness of the precipitation of a mineral water, by the addition of ammoniacal gas, therefore affords the means of ascertaining the nature of the earthy salt decomposed by this gas. In general, salts with base of magnesia, are much more usually met with than those with base of aluminous earth. Bergman has observed, that ammoniac is capable of forming with sulphat of magnesia a compound, in which a portion of this neutral salt is combined, without decomposition, with a portion of ammoniacal sulphat. This non-decomposed portion of sulphat of magnesia may probably form with the ammoniacal sulphat a mixed neutral salt, similar to the ammoniaco-mercurial muriat, or *sal alembroth*. The ammoniac does not, therefore, precipitate the whole of the magnesia, and consequently does not accurately exhibit the quantity of *Epsom salt*, of which that earth is the base. For this reason lime water, in my opinion, is preferable for ascertaining the nature and quantity of salts with base of magnesia contained in mineral waters. It has likewise the property of precipitating the salts with aluminous base much more abundantly and readily than ammoniacal gas.*.

The concentrated sulphuric acid precipitates a white powder from water which contains barytes, according to Bergman; but, as the same chemist observes, that this earth is seldom found in mineral waters, it will not be necessary to enlarge on the effects of this re-agent. When it produces an effervescence, or bubbles in water, it indicates the presence of chalk, carbonat of soda, or pure carbonic acid: each of these substances may be distinguished by certain peculiar phenomena. If water containing chalk be heated after the addition of sulphuric acid, a pellicle and deposition of sulphat of lime are soon formed, which does not happen with waters which are simply alkaline. At first consideration it may seem that the

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* It may be observed, that I repeat many facts already explained in the course of this work, which I have thought proper to do, in order to render this small treatise on the analysis of mineral waters more perspicuous and complete, and to collect, in one view, all the knowledge which appears to be indispensably necessary to be possessed by such as undertake this species of analysis.

fulphat of lime ought to be precipitated as soon as the sulphuric acid is poured into water containing chalk ; this, however, very seldom happens without the assistance of heat, because these waters most commonly contain a superabundance of carbonic acid which favours the solution of the fulphat of lime, and of which it is necessary to deprive them before the salt can be precipitated. This fact may be shown, in the clearest manner, by pouring a few drops of concentrated sulphuric acid into a certain quantity of lime water which has been precipitated, and afterwards rendered clear by the addition of carbonic acid : if the lime water be highly charged with regenerated calcareous earth, a precipitate of fulphat of lime is thrown down in a few minutes, or more slowly in proportion as the carbonic acid is set at liberty. If no precipitate be afforded by standing, as will be the case when the quantity of fulphat of lime is very small, and the superabundant carbonic acid considerable, the application of a slight degree of heat will cause a pellicle of calcareous fulphat, and a precipitate of the same nature to be formed.

The nitrous acid is recommended by Bergman to precipitate sulphur from *hepatized* waters. The experiment may be made by pouring a few drops of the brown and fuming acid on distilled water, in which the gas disengaged from caustic alkaline sulphure, heated in a retort, has been received. This artificial *hepatic* water, which does not considerably differ from natural sulphureous waters, except in the circumstance of its being more difficult to filter, and its always appearing somewhat turbid, affords a precipitate in a few seconds, by the addition of nitrous acid ; the precipitate is of a yellowish white ; when collected on a filter and dried, it burns with the flame and smell of sulphur, and in other respects has every character of that inflammable body. Nitrous acid seems to alter sulphurated hydrogen gas in the same manner as it does all other inflammable substances, by virtue of the great quantity of oxygen it contains. Scheele has recommended the oxygenated muriatic acid to precipitate the sulphur from waters of this nature ; only a very small quantity of it must be used, otherwise the sulphur will be burned and reduced to the state of sulphuric acid, as I have observed of the water of Montmorency. Sul-

phureous acid precipitates the sulphur very readily from waters which contain it.

There are few re-agents, whose mode of action is less known than that of the alkaline lixivium of blood, which has been called *phlogificated alkali*; it has been long since ascertained, that this liquor contains Prussian blue, or prussiat of iron, ready formed; it has been thought that this blue might be separated by the addition of an acid; and in this state it has been proposed as a substance capable of exhibiting iron existing in mineral waters. Nothing can be more uncertain than the complete separation of prussiat of iron from this prussiat of potash made with blood. This lixivium ought therefore to be no longer used as a re-agent. Macquer having discovered that Prussian blue is decomposed by alkalis, proposed potash saturated with the colouring matter of this blue, as a test to ascertain the presence of iron in mineral waters. But as the liquor itself likewise contains a small quantity of Prussian blue, which may be separated by means of an acid, as Macquer has shown, Baumé advises that two or three ounces of distilled vinegar be added to each pound of this Prussian alkali, and digested in a gentle heat, till the whole of the Prussian blue is precipitated; after which pure fixed alkali is to be added to saturate the acid of vinegar. Notwithstanding this ingenious process, I have observed, that the Prussian alkali, purified by vinegar, deposits Prussian blue in process of time, more especially by evaporation. M. Gioanetti made the same observation by evaporating the Prussian alkali, purified, by the method of Baumé, to dryness: he has proposed two processes for obtaining this liquor in a state of purity, and totally exempt from iron; the one consists in supersaturating the Prussian alkali with distilled vinegar, evaporating it to dryness by a gentle heat, dissolving the remaining mass in distilled water, and filtering the solution; all the Prussian blue remains on the filter, and the liquor which passes through contains none at all. The other process consists in neutralizing the alkali with a solution of alum, from which, after filtering, the sulphat of potash is separated by evaporation. These two liquors do not afford a particle of Prussian blue with the pure acids, nor by evaporation to dryness. The lime water, saturated with the colour-

ing matter of Prussian blue, mentioned by us, in treating on iron, does not require these preliminary operations: when poured on a solution of sulphat of iron, it immediately forms pure Prussian blue without any mixture of green. Acids only precipitate a few particles of Prussian blue from this reagent; it therefore does not contain iron, and consequently is preferable to the Prussian alkalis, in the assay of mineral waters. This phenomenon doubtless depends on the action of the lime, which, when dissolved in water, is far from having the same efficacy on iron as alkalis have. This prussiat of lime seems to be exceedingly well adapted to distinguish ferruginous waters, whether they be gaseous or sulphuric. In fact, the carbonic gas, which holds iron in solution in waters being of an acid nature, decomposes Prussian lixiviums by the way of double affinity, as well as sulphat of iron. I have tried prussiat of lime on Spa waters, and those of Passy, and I immediately obtained a very perceptible blue in the former, and very abundant in the latter. This, therefore, is a liquor very easily prepared, which does not contain the smallest portion of Prussian blue, and is exceedingly well calculated to exhibit the presence of small quantities of iron in waters. It is a kind of neutral salt, formed by the prussic acid, or the colouring part of the blue and lime. I have observed, in the foregoing part of this work, in treating of iron, that Scheele made the same inferences as myself concerning the utility of this proof liquor, which was mentioned by me as early as the year 1780.

Nut-galls, as well as all other bitter and astringent vegetables, such as oak bark, the fruit of the cypress tree, the husks of nuts, &c. have the property of precipitating solutions of iron, and exhibiting that metal of different colours, according to its quantity, its state, and that of the water in which it is dissolved. This colour in general is of all shades, from a pale rose to the deepest black. It is well known that the purple colour, assumed by waters, with the tincture of nut-galls, is not a proof that they contain iron in its metallic state, since the sulphat and carbonat of iron likewise assumes a purple colour by the infusion of nut-galls. The differences of colour observed in these precipitations, depend rather on the quantity of iron, its greater or less degree of adhesion to the water, and

the more or less advanced state of decomposition of the solution, relatively to the quantity of oxygen contained in the iron. We have already observed, that the astringent principle is a peculiar acid, since it unites with alkalis, converts blue vegetable colours to a red, decomposes alkaline sulphures, and combines with metallic oxyds. Nut-galls in powder, the infusion of this substance in water, made without heat, and the tincture by alcohol, are used to ascertain the presence of iron in mineral waters. The tincture is preferred, because it is not subject to become mouldy as the aqueous solution is. The distilled products of nut-galls likewise colour ferruginous solutions. The infusions in acids, alkalis, oils, and ether exhibit the same phenomenon. The iron precipitated by this matter from acids is in the state of gallat of iron, and forms a kind of neutral salt, which, though very black, is not attracted by the magnet. It dissolves slowly, and without sensible effervescence in acids, but loses these properties by the action of fire, and is then attracted by the magnet. The nut-gall is so efficacious a re-agent, that a single drop of its tincture colours in the space of five minutes, with a purple tinge, three pints of water, which contains only the twenty-fifth part of a grain of sulphat of iron. All these phenomena proceed from the great facility with which the matter of nut-galls burns, and from its readily absorbing from the iron a portion of the oxygen it contains, passing by this means to the state of a black oxyd or Ethiops, the smallest quantity of which is very perceptible in transparent liquors.

The two last re-agents we shall propose for the examination of waters, are solutions of silver and of mercury in the nitric acid. These have usually been employed to exhibit the presence of the sulphuric, or muriatic acids in mineral waters; but many other substances, which do not contain the smallest portion of those, are likewise precipitated by these solutions. The white and heavy strice which the nitrat of silver exhibits in water, that contains no more than half a grain of muriat of soda in the pint, ascertains the presence of the muriatic acid with great certainty and facility; but they do not in the same manner indicate the presence of the sulphuric acid, since, according to Bergman's estimate, at least thirty grains of sulphat

of soda must exist in the pint of water, in order to produce an immediate sensible effect. To this we may add, that fixed alkali, chalk, and magnesia, precipitate the nitric solution of silver in a much more evident manner, and consequently that the precipitation formed in a mineral water by this solution is insufficient to determine with precision, the saline or earthy substances from which it arose.

The solution of mercury by the nitric acid, is still more productive of error: it not only indicates the presence of the sulphuric and muriatic acids in waters, but it is likewise precipitated by the earthy and alkaline carbonats, in a yellowish powder, which might be mistaken for an effect of the sulphuric acid. It has been commonly supposed, that the very abundant white precipitate which it forms in water, is owing to the presence of a muriatic salt; yet mucilaginous and extractive substances exhibit the same phenomenon, as is now well known to all chemists. Besides, these sources of error and uncertainty, dependent on the property which several substances have, of producing similar precipitates with the nitric solution of mercury, there are likewise others which depend on the state of this solution itself, and which it is of the utmost consequence to know, in order to avoid very considerable errors in the analysis of waters. Bergman has mentioned some of the remarkable differences observed in this solution, according to the manner in which it is made, either with or without heat, more particularly with respect to the colour of the precipitates it affords by different intermediums; but he does not say a word concerning the property this solution possesses, of being precipitated by distilled water, when it is highly charged with the oxyd of mercury; though Monnet mentioned this fact in his treatise on the dissolution of metals. As this subject is of great importance in the analysis of waters, I have endeavoured by a very minute investigation to arrive at some degree of certainty concerning it, and I have succeeded as shall presently appear by very simple means. I have made a great number of solutions of mercury, in very pure nitric acid, with different doses of these two substances, with heat and in the cold, and with acids of very different strengths. These experiments have afforded the following results.

1. Solutions made in the cold, became charged more or less readily with different quantities of mercury, according to the degree of concentration of the nitric acid; but whatever the quantity of mercury dissolved in the cold by the concentrated acid may be, no part of it will be precipitated by mere water. I have dissolved in the cold two drachms and a half of mercury, in two drachms of nitrous acid red and fuming, weighing one ounce four drachms and five grains, in a bottle which contained an ounce of distilled water: the combination took place with the utmost rapidity; very dense nitrous gas escaped, together with aqueous vapours, dissipated by the heat of the mixture, amounting to more than one-fourth of the acid. This solution was of a deep green, and very transparent. I poured a few drops into half an ounce of distilled water: some white striae were formed, which were dissolved by agitation, and afforded no precipitate, though it was the most saturated solution I could make in the cold, and presented the greatest degree of commotion, effervescence, and red vapours, during the combination of the mercury and acids. As it had deposited crystals, I added two drachms of distilled water, which dissolved the whole without any appearance of precipitation. With much greater safety, therefore, may such solutions, as have been made in the cold with common nitric acid, and half their weight of mercury, be used in the analysis of mineral waters, for they will never afford a precipitate by the addition of mere water.

2. The weakest nitric acid strongly heated on mercury, will dissolve a larger quantity than the strongest acid in the cold; the solution, which is of a light yellow colour, will appear thick and oily, and will afford by standing, an irregular yellowish mass, which may be changed into a beautiful *turbith* by the addition of boiling water; this solution poured into distilled water, forms a very abundant precipitate of a yellow colour, similar to *turbith*. A solution made in the cold, exhibits the same result, if it be strongly heated, so as to disengage a large quantity of nitrous gas. These solutions made with heat, ought therefore to be excluded from the analysis of mineral waters, because they are decomposable by distilled water.

3. The two solutions appear to differ from each other in the

quantity of oxyd of mercury, which is much greater in that which is precipitated by the water, than in that which is not decomposable by that fluid. I have proved this, by evaporating equal quantities of both these solutions in an apothecary's phial, to reduce them into red precipitate, and I obtained one-fourth more of this precipitate from the solution, which is decomposed by water, than from that which is not rendered turbid. The specific gravity likewise appeared to me to be a good method of ascertaining the relative quantities of oxyd of mercury contained in these different fluids. I compared weights of equal masses of three mercurial nitrous solutions; the one, which was not at all precipitated by distilled water, and was the result of the first mentioned experiment, weighed one ounce one drachm and sixty-seven grains, in a bottle which contained exactly an ounce of distilled water. The second solution was made by a very gentle heat, and produced a slight opal colour with distilled water, and scarcely any sensible quantity of precipitate. The same bottle contained one ounce six drachms twenty-four grains. Lastly, A third mercurial solution considerably heated, and which precipitated a true *turbid mineral* of a dirty yellow, by distilled water, weighed in the same bottle, one ounce seven drachms twenty-five grains. A decisive experiment remained to be made to confirm this opinion still more perfectly: if the solution precipitated by water, owed this property to a quantity of mercurial oxyd, too large with respect to the acid, it would of course lose that property by the addition of acid; this accordingly happened. Aquafortis was poured on a solution which was decomposed by water, and it soon acquired the property of no longer being precipitated, and was absolutely in the same state as that which had been made slowly at first, by the mere heat of the atmosphere. Monnet has mentioned this process, as a means of preventing crystals of mercurial nitrat from becoming converted into oxyd by the contact of the air. It is by a contrary process, and by evaporating a portion of the acid of a good solution, which is not precipitated by water, that it is converted into a solution much more strongly charged with mercurial oxyd, and consequently capable of being decomposed by water; its original property may be restored by the

addition of a quantity of acid, equal to that which it lost by evaporation.

Such are the different considerations which I have thought it necessary to exhibit, that the effects of re-agents on waters may be better ascertained; but whatever may be the degree of precision to which researches of this nature may be carried; however extensive the knowledge we may have acquired concerning the degrees of purity, and the different states of such substances as are combined with mineral waters, for the purpose of discovering their principles, if it still remains a fact that each of these re-agents is capable of indicating two or three different substances dissolved in these waters, the result of their action will always be subject to uncertainty. Lime, for example, seizes the carbonic acid, and precipitates salts with the base of alumine, and of magnesia, as well as the metallic salts. Ammoniac produces the same effect. Fixed alkalis, besides the above-mentioned salts, precipitate those with base of lime. The calcareous prussiat, the prussiat of potash and gallic alcohol, precipitate the sulphat and carbonat of iron. The nitric solutions of silver and of mercury, decompose all the sulphuric and muriatic salts, which may be various both in quantity and in kind, in the same water, and are themselves decomposable by alkalis, chalk, and magnesia. Among this great number of complicated effects, how shall we distinguish that which takes place in the water under examination, or by what means shall we ascertain whether it is simple or compounded?

These questions, though very difficult, for the time when the expedients of chemistry were little known, are nevertheless capable of being discussed in the present state of our knowledge. I must first observe, that the nature of re-agents being much better known at present than it was some years ago, and their re-action on the principles of water better ascertained, it may, therefore, be strongly presumed that their application may be much more advantageously made than has hitherto been supposed: nevertheless, among the great number of excellent chemists who have attended to the analysis of waters, Messrs. Baumé, Bergman, and Gioanetti, are almost the only persons who have been aware of this great advantage. We have been

long in the habit of examining mineral waters by re-agents, in very small doses, and often in glasses: the phenomena of the precipitations observed have been noted down, and the experiment carried no further. Baumé advises, in his chemistry, that a considerable quantity of the mineral water, under examination, should be saturated with fixed alkalis and with acids, that the precipitates be collected, and their nature examined. Bergman apprehended that the quantity of the principles contained in waters might be judged of from the weight of the precipitates obtained in these mixtures. Several other chemists have likewise employed this method, but always with a view to certain particular circumstances; and no one has hitherto proposed to make a connected analysis of mineral waters by this means. To succeed in this analysis, I think it would be proper to mix several pounds of the mineral water with each re-agent, till the latter ceases to produce any precipitate; the precipitate should then be suffered to subside during the time of twenty-four hours, in a vessel accurately closed; after which the mixture being filtered, and the precipitate dried and weighed, the operator may proceed to examine it by the known methods. In this manner the nature of the substance will be clearly ascertained, on which the re-agent has acted, and the cause of the decomposition may consequently be inferred. A certain order may be followed in these operations, by mixing the waters first with such substances as stand least capable of altering them, and afterwards passing to other substances capable of producing changes more varied and difficult to explain. The following method is that which I commonly use in this kind of analysis. After having examined the taste, the colour, the weight, and all the other physical properties of a mineral water, I pour four pounds of lime water on an equal quantity of the fluid; if no precipitate is made in twenty-four hours, I am sure that the water contains neither disengaged carbonic acid, nor alkaline carbonat, nor earthy salts with the base of aluminous earth or magnesia, nor metallic salts. But if a precipitate be formed, I filter the mixture, and examine the chemical properties of the deposited substance; if it has no taste, if it be insoluble in water, or effervesces with acids, or forms an insipid and almost insoluble salt by the addition of sulphuric

acid, I conclude that it is chalk, and that the lime water has acted only on the carbonic acid dissolved in the water. If, on the contrary, it is small in quantity, and subsides very slowly; if it do not effervesce, and affords with the sulphuric acid a styptic salt, or a bitter and very soluble salt, it is formed by magnesia or aluminous earth, and often by both. I need not enter at large into the means of distinguishing these two substances from each other, as they are sufficiently explained in the foregoing part of this work. I shall only add, that a sufficient number of experiments ought to be made, to leave no doubt respecting their nature.

After the examination by lime water, I pour on four other pounds of the same mineral water, a drachm or two of ammoniac perfectly caustic, or I cause ammoniacal gas, disengaged by heat from the alkali, to pass into the water. When the water is saturated, I leave it at rest in a close vessel for twenty-four hours; if a precipitate be afforded, it can only consist of ferruginous or magnesian, or aluminous salts, whose nature I examine by the different methods mentioned in the foregoing paragraph. But the action of ammoniacal gas being more fallacious than that of lime water, which produces the same decompositions, it must be observed that this last should only be used as an assistant means, which does not afford results equally accurate with those produced by the former re-agent.

When salts with base of aluminous earth, or magnesia, have been discovered by lime water, or by ammoniacal gas, the caustic fixed alkalis may be used, to distinguish those with base of lime, such as sulphat and muriat of lime: for this purpose I precipitate some pounds of the water, which I examine by either of these liquid alkalis, till it no longer produces any turbidness. As this alkali decomposes salts with base of aluminous earth, as well as those composed of lime: if the precipitate resembles in its form, colour, and quantity, that which lime water has afforded, it may be presumed that the water does not contain calcareous salt, and the chemical examination of the precipitate usually confirms this suspicion; but if the mixture is much more turbid than that made with lime water; if the deposition be much heavier, more abundant, and more readily afforded, the lime is mixed with magnesia or alumine.

I ascertain this by treating the precipitate after the different methods before explained. It may easily be concluded, that iron precipitated by re-agents, at the same time as the saline-terrestrial substances, is easily known by its colour and its taste; and that the small quantity of this metal separated in these processes, is not sufficient to affect the results.

It were useless to explain at large, the effects of sulphuric acid, nitrous acid, gall-nuts, or of the calcareous and alkaline prussiate, employed as re-agents on mineral waters. The general account of these effects which I have already given may suffice; I shall therefore only add, that when they are mixed in large doses with these waters, and the precipitates collected, the nature and quantity of their principles, may be more accurately ascertained, as has been done by Messrs. Bergman and Gioanetti. But I shall dwell some time on the products which the nitric solutions of silver or mercury afford when mixed with mineral waters. It is more particularly necessary to operate with large quantities of water, when these re-agents are used, in order to determine the nature of the acids contained in the waters. The analysis of these fluids will be complete when their acids are known, because these are often combined with the bases exhibited by the re-agents before-mentioned. The colour, the form, and the abundance of the precipitates afforded by the nitric solutions of mercury and silver, have hitherto exhibited to chemists the nature of the acids which caused them. A thick and ponderous deposition immediately formed by these solutions, denotes the muriatic acid: if it is small in quantity, white, and crystallized with the nitrate of silver, or yellowish, and yellow and irregular when formed with that of mercury, and if it subsides but slowly, it is attributed to the sulphuric acid. But, as these two acids are often met with in the same water, and as alkali and chalk likewise decompose the solutions, the results or deductions made from the physical properties of the precipitates must be uncertain. It is therefore necessary to examine them more effectually; for this purpose, solutions of silver or of mercury, may be mixed with five or six pounds of the water intended to be analyzed. The mixtures being filtered, twenty-four hours after, the precipitates must be dried, and treated according to

the methods of chemistry. If the precipitate afforded by the nitric solution of mercury be heated in a retort, the portion of metal united with the muriatic acid of the waters will be volatilized into *mercurius dulcis*, and that which is combined with the sulphuric acid will remain at the bottom of the vessel, and exhibit a reddish colour. These two salts may likewise be distinguished by putting them on a hot coal: the sulphat of mercury, if present, emits a sulphureous acid, and assumes a red colour; the mercurial muriat remains white, and is volatilized without exhibiting any smell of sulphur. These phenomena likewise serve to distinguish the precipitates which may be formed by the alkaline substances contained in water, since the latter do not emit the sulphureous smell, and are not volatile without decomposition.

The precipitates produced by the combination of mineral waters with the nitric solution of silver, may be as easily examined as the foregoing. Sulphat of silver being more soluble than the muriat of the same metal, distilled water may be successfully used to separate these salts. Muriat of silver is known by its fixity, its fusibility, and especially in its being less easily decomposed than sulphat of silver. This last, placed on hot coals, emits a sulphureous smell, and leaves an oxyd of silver, which may be fused without addition. I do not here speak of all the processes chemistry affords for separating or distinguishing the two salts here mentioned: it is sufficient that I have pointed out some of them.

§ VI. *The Examination of the Mineral Waters by Distillation.*

Distillation is used in the analysis of waters, to ascertain the gaseous substances they may be united to. These substances are either air, more or less pure, or carbonic acid, or sulphurated hydrogen gas. To ascertain their nature and quantity, some pounds of the mineral water must be poured into a retort, sufficiently large to contain it, without being filled more than half or two-thirds of its capacity; to this vessel a recurved tube is to be adapted, which passes beneath an inverted vessel filled with mercury. In this disposition of the apparatus, the retort must be heated till the water perfectly boils, or till no more elastic fluid passes over. When the operation is finished, the quantity

of air contained in the empty space of the retort must be subtracted from the bulk of the gas obtained; the rest consists of aeriform fluid, which was contained in the mineral water, whose properties may quickly be known by the proofs of a lighted taper, tincture of turnsole, and lime water; if it catches fire, and has a fetid smell, it is sulphurated hydrogen gas; if it extinguishes the taper, reddens turnsole, and precipitates lime water, it is the carbonic acid; lastly, if it maintains combustion without taking fire, is without smell, and alters neither turnsole nor lime water, it is atmospheric air. It may happen that this last fluid may be purer than the air of the atmosphere: in this case its degrees of purity may be judged by the manner in which it maintains combustion, or by mixing it with nitrous or hydrogen gas, in the eudiometers of Fontana and Volta. The process used in obtaining gaseous matters, contained in waters, is entirely modern. A moistened bladder was formerly used, which was adapted to the neck of a bottle filled with mineral water; the fluid was agitated, and by the swelling of the bladder, an estimate was made of the quantity of gas contained in the water. This method is now known to be fallacious, because water cannot give out all its gas but by ebullition, and because the sides of the moistened bladder alter and decompose the elastic fluid obtained. It is scarcely necessary to remark, that the phenomena exhibited by the water, during the escape of the gas, must be carefully examined, and that a less quantity of water may be exposed to distillation, in proportion as its taste and sparkling indicate that it contains a larger quantity of gas.

Such is the method recommended by modern chemists to obtain the elastic fluids combined with waters: I must observe, 1. That this process cannot be depended on, with regard to acidulous waters, unless the pressure of the atmosphere, and the state of compression of the elastic fluid under the glass vessels, be more accurately accounted for; and as this is not easily done, the absorption of carbonic acid by lime water, proposed by Gioanetti, appears to be preferable. 2. Though it has been recommended by Bergman to obtain sulphurated hydrogen gas from sulphureous waters, it does not answer, because the heat of ebullition decomposes the gas, and it is likewise de-

composed by the mercury, which is converted into ethiops, as soon as it comes in contact with this elastic fluid: for this reason, in my analysis of the waters of Enguien, near Montmorency, I have proposed litharge to absorb this gas in the cold, and to deprive sulphureous waters of their sulphur.

§ VII. *The Examination of Mineral Waters by Evaporation.*

Evaporation is generally considered as the most certain method of obtaining all the principles of mineral waters. We have before observed, and here repeat, that the experiments of Venel and Cornette show that long continued ebullition may decompose saline matters dissolved in water, and for that reason we have advised the examination of them by re-agents, employed in greater proportions: yet evaporation may afford much information, when used, together with the analysis by re-agents, which ought always to be considered as one of the principal methods of examining waters.

The intention of evaporation being to collect the fixed principles contained in a mineral water, it is obvious, that in order to know the nature and proportion of these principles, a considerable quantity of the water must be evaporated, and so much the more, in proportion as the principles appear to exist in smaller quantities. When the water is thought to contain a large quantity of saline matter, about twenty pounds must be evaporated; if, on the contrary, it appears to hold but a very small quantity in solution, it will be necessary to evaporate a much larger quantity. It is sometimes requisite to perform this operation with several hundred pounds. The nature and form of the vessels, in which waters are exposed for evaporation, is not a matter of indifference. Those of metal, excepting silver, are altered by water; vessels of glass, of a certain magnitude, are very subject to be broken; but those of glazed, smooth pottery are the most convenient, though the cracks in the glaze sometimes cause an absorption of saline matter; vessels of unglazed porcelain, called bisquit, would doubtless be the most convenient, but their price is a considerable obstacle. Chemists have proposed different methods of evaporating mineral waters; some have directed distillation to dryness, in close vessels, in order to prevent foreign substances, which float in

the atmosphere, from mixing with the residue; but this method is excessively tedious: others have advised evaporation by a gentle heat, never carried to ebullition, because they supposed that this last heat alters the fixed principles, and carries up a portion of them. This was the opinion of Venel and Bergman. Monnet, on the contrary, directs the water to be boiled, because this motion prevents the reception of foreign matters contained in the atmosphere. Bergman avoids this inconvenience, by directing the vessel to be covered, and a hole left in the middle of the cover for the vapours to pass out: this last method greatly retards the evaporation, because it diminishes the surface of the fluid. At the commencement, the heat used must be sufficient to repel the dust; but the greatest difference in the manipulation of this experiment consists in some writers directing, that the substances deposited should be separated, as the evaporation proceeds, in order to obtain each pure and by itself; others, on the contrary, direct the operation to be carried on to dryness. We are of the opinion of Bergman, that this last method is the most expeditious and certain; because, notwithstanding the care which may be taken, in the first method, to separate the different substances, which are deposited or crystallized, they are never obtained pure, and must always be examined by a subsequent analysis; and the method is besides inaccurate, on account of the frequent filtrations, and the loss it occasions. Lastly, It is very embarrassing, and renders the evaporation much longer. Mineral waters may therefore be evaporated to dryness, in open glass vessels, on the water-bath, or still more advantageously in glass retorts, on a sand-bath.

Various phenomena are observed during this evaporation; if the water be acidulous, it emits bubbles, as soon as the heat first begins to act; in proportion as the carbonic acid is disengaged, a pellicle is formed, with a deposition of calcareous earth, and carbonat of iron. These first pellicles are succeeded by the crystallization of sulphat of lime; and lastly, the muriats of potash and soda crystallize in tubes at the surface, but the deliquescent are not obtained but by evaporation to dryness.

The residue must then be weighed, and put into a small vial, with three or four times its weight of alcohol: the whole be-

ing agitated, and suffered to subside for some hours, must be filtrated, and the alcohol preserved separate. The residue, on which the spirit has not acted, must be dried in a gentle heat, or in the open air; when perfectly dry, it must be weighed, and the loss of weight will show what quantity of calcareous or magnesian muriat was contained, because these salts are very soluble in alcohol. We shall presently speak of the method of ascertaining the presence of these two salts in the spirituous fluid.

The residue, after treatment with alcohol, and drying, must be agitated with eight times its weight of cold distilled water, and filtered. After some hours standing, the residue is to be dried a second time, and boiled half an hour in four or five hundred times its weight of distilled water: this last residue, after filtration, consists of that which cold or boiling water is insufficient to dissolve. The first water contains neutral salts, such as sulphat of soda, or of magnesia; the muriat of soda, or potash and the fixed alkalis, especially soda united with carbonic acid: the large quantity of boiling water scarcely contains any substance but sulphat of lime. There are therefore four substances to be examined, after these different operations on the matter obtained by evaporation. 1. The residue insoluble in alcohol, and in water of different temperatures. 2. The salts dissolved in alcohol. 3. The salts dissolved in cold water. 4, and lastly, Those dissolved in boiling water. We shall now proceed to the experiments necessary to ascertain the nature of these different substances.

1. The residue which has resisted the action of the alcohol and water, may be composed of calcareous earth, of carbonat of magnesia and iron, of alumine, and of quartz. These two last substances are seldom found in waters, but the three first are very common; the brown, or more or less deep yellow colour, indicates the presence of iron. If the residue be of a white gray, it does not contain this metal. When iron is present, Bergman directs it to be moistened, and exposed to the air till it rusts; in which state vinegar does not act on it. In order to explain the methods of separating these different substances, we will suppose an insoluble residue to consist of the five substances here mentioned; it must first be moistened, and

exposed to the rays of the sun ; and when the iron is perfectly rusted, the residue must be digested in distilled vinegar. This acid dissolves the lime and magnesia, and by evaporation affords the calcareous acetit, distinguishable from the acetit of magnesia, by its not attracting the humidity of the air. They may consequently be separated by deliquescence, or by pouring sulphuric acid into their solution. The latter forms sulphat of lime, which precipitates ; but if the magnesian acetit be present, the sulphat of magnesia, composed of magnesia united with the sulphuric acid, will remain in solution, and may be contained by a well conducted evaporation. To ascertain the quantity of magnesia and calcareous earths contained in this residue, sulphat of lime is first to be precipitated ; and the sulphat of magnesia, formed by the sulphuric acid poured into the acetous solution, must then be precipitated by carbonat of potash. The quantities of these precipitates are known by weighing. When the chalk and magnesia of the residue are thus separated, the iron, the alumine, and the quartz remain. The iron and the alumine are dissolved by pure muriatic acid, from which the former is precipitated from prussiat of lime, and the latter by carbonat of potash. These precipitates must likewise be weighed. The matter which remains after the separation of the alumine and iron is usually quartzose : its quantity may be known by weighing, and its habitudes by fusion of the blow-pipe with carbonat of soda. Such are the most accurate processes, recommended by Bergman, for examining the insoluble residue of waters.

2. The alcohol used in washing the solid residue of mineral waters, must be evaporated to dryness. Bergman advises treating it with sulphuric acid diluted with water in the same manner as the acetous solution before-spoken of ; but it must be observed, that this process serves only to exhibit the bases of these salts. To determine the acid, which is ordinarily united with magnesia or lime, and sometimes with both, a few drops of concentrated sulphuric acid must be poured on, which excites an effervescence, and disengages the muriatic acid gas, known by its smell and white vapour, when the salt under examination contains that acid. This may likewise be known by dissolving the whole residue in water, and adding a few drops of the ni-

tric solution of silver. The nature of the base, which, as we have observed, is either lime, magnesia, or, both together, is known by the name of the sulphuric acid, by a similar process with that already explained respecting the acetous solution.

3. The water used in washing the first residue of the mineral water, performed, as before directed, with eight times its weight of cold distilled water, contains neutral alkaline salts, such as sulphat of soda, muriats, or marine salts, carbonat of potash, and of soda, and sulphat of magnesia: a small quantity of sulphat of iron is sometimes found. These salts never exist altogether in waters: the sulphat of soda, and the carbonat of potash, are very seldom found; but marine salt is frequently met with, together with carbonat of soda. The sulphat of magnesia is likewise frequently met with, and some waters even contain it in considerable quantities. When the first washing of the residue of a mineral water contains only one kind of neutral salt, it may easily be obtained by crystallization, and its nature ascertained from its form, taste, and the action of fire, as well as that of the reagents: but this case is very rare, for it is much more usual to find many salts united in this lixivium. They must therefore be separated, if practicable, by slow evaporation; but as this method does not always perfectly succeed, however carefully this evaporation be conducted, it will be necessary to re-examine the salts obtained at the different periods of the evaporation. Carbonat of soda is usually deposited confusedly with the muriatic salts, but they may be separated by a process, pointed out by M. Gioanetti. It consists in washing this mixed salt with distilled vinegar; for this acid dissolves the carbonat of soda. The mixture must then be dried and washed a second time with alcohol, which takes up the acetit of soda, without acting on marine salt. The spirituous solution being evaporated to dryness, and the residue calcined, the vinegar becomes decomposed and burns. Soda alone remains, whose quantity may be then accurately determined.

4. The water used in the quantity of four or five hundred times the weight of the residuum of the mineral water contains only sulphat of lime. This may be ascertained by pure caustic ammoniac, which occasions no change, while caustic pot-

ash precipitates it abundantly. By evaporation to dryness, the quantity of earthy salt contained in the water may be accurately ascertained.

§ VIII. *Concerning Artificial Mineral Waters.*

The numerous processes we have prescribed for examining the residues of mineral waters by evaporation, serve to ascertain, with the greatest precision, all the several matters held in solution in these fluids. Another process remains to be made to prove the success of the analysis, viz. That of imitating nature in the way of synthesis, by dissolving in pure water the different substances obtained by the analysis of mineral water which has been examined. If the artificial mineral water has the same taste, the same weight, and exhibits the same phenomena with re-agents as the natural mineral water, it is the most complete, and the most certain proof that the analysis has been well made. This artificial combination has likewise the advantage of being procured in all places at pleasure, and at a trifling expence; and is even in some cases superior to the natural mineral waters, whose properties may be changed by carriage, and other circumstances. The most celebrated chemists are of opinion, that it is possible to imitate mineral waters. Macquer has observed, that since the discovery of the carbonic acid, and the property it is found to possess of rendering many substances soluble in water, it is much more easy to prepare artificial mineral waters. Bergman has described the method of composing waters, which perfectly imitate that of Spa, Sheltzer, Pyrmont, &c. He likewise informs us, that they are used with great success in Sweden, and that he himself has experienced their good effects. Duchanoy has published a work, in which he has given a number of processes for imitating all the mineral waters usually employed in medicine. We may therefore hope, that chemistry may render the most essential service to the art of healing, by affording valuable medicines, whose activity may be increased or diminished at pleasure.

A
DISCOURSE

ON

MODERN CHEMISTRY IN GENERAL, AND ON ITS FIRST
PRINCIPLES.

IN tracing the progress which chemistry has made during the last twenty years, we find, that the theory of Stahl, overturned by the discovery of the different elastic fluids, and their properties, has left chemists for some time in doubt, whether to reject or adhere to it, and has given rise to theories, the number of which is scarcely inferior to those who are seriously engaged in this science. A very considerable number of these chemists, especially in the north, have not yet adopted any new theory, but continue to connect the theory of phlogiston with the newly discovered facts. But those who are masters of the science in all its extent, must readily perceive, that the manner in which that connection is formed, is far from being natural or satisfactory; and that it consists of forced analogies, the inconsistency of which is sufficiently striking.

The doctrine adopted by several French chemists; at the head of whom we must rank Lavoisier, who first laid the foundations, and who invented almost the whole of this system, is not subject to the same difficulties. Its simplicity, its systematic progress, its perspicuity, and the ease with which it is ap-

plicable to all the phenomena of chemistry, render it much superior to any of those which still divide such of the philosophers of Europe as have not adopted it.

Among the more celebrated of its partisans, this doctrine now reckons the names of La Grange, La Place, Black, Kirwan, Van Marum, Berthollet, Monge, Morveau, Chaptal, Charles, Landriani, Schurer, Girtanner, Jacquin the son, Arezula, &c. &c. I have taught this doctrine both in my public and private lectures for these last twelve years. If I may be permitted to flatter myself, that I have contributed in some degree to elucidate this system of modern chemical science, either by my lectures and writings, or by such discoveries as I have published within these fifteen years, I must be permitted to observe, that no other theory affords so true and full an explanation of all the phenomena of nature and of the arts.

This doctrine has been exposed at large in all the parts of this elementary work. But as it may be of advantage to exhibit a short and condensed view of the subject, I thought that, by uniting, in a discourse of no great length, the principles upon which it is founded, it would become more striking and clear to those who devote themselves to the study of this science; and that this discourse would be so much the more useful to them, as it exhibits a recapitulation of the great phenomena to which all the rest may be referred, as to general heads.

There is not a single experiment in chemistry in which one or the other of the two following phenomena does not happen. 1. Caloric is disengaged or fixed. 2. An elastic fluid is formed, or absorbed, or its base passes from one fluid into another.

These two general facts being once established and clearly known, it will be seen, that the foundation of chemical theory depends on the properties and the action of heat, the formation and fixation of elastic fluids. It is therefore upon these two objects that our whole attention ought to be fixed.

Concerning Heat, the Formation and Fixation of Elastic Fluids.

Although the weight which has been hitherto undetermined of free or combined caloric, cannot prove its material or particular existence, yet all the phenomena of chemistry unite in

favour of this opinion, that it is a being or body self-existent, possessing constant properties or characters, and obeying inviolable attractions in similar circumstances. Besides the sensation common to all men, which caloric causes our organs to experience, philosophers have discovered distinctive properties which belong only to this substance. Such is the rarefaction or separation of the particles which heat produces in all natural bodies; and which, by augmenting their volume, diminishes their attraction to each other, while it diminishes their specific gravity without adding to their mass, and increases their attraction for the particles of other bodies. The more caloric is accumulated in bodies, the more it is compressed or condensed, the more its particular attraction for these bodies increases, and the more their properties are changed. Fusion or liquefaction, volatilization or sublimation, the transition of liquids to the form of vapours or elastic fluids, are the constant effects of the penetration, or rather the combination of caloric. Solid or frozen water, by absorbing a certain quantity of caloric, becomes liquid or flowing: a greater dose of this principle renders it invisible, and gives it the form of air. It cannot be doubted, but that liquid water is a compound of ice, and a determinate quantity of caloric; and that water in vapour or gas is the same combination, with a larger proportion of caloric. Such is the general theory of the formation of all elastic fluids: they are all composed of a base more or less solid and caloric. As this last principle follows laws which are peculiar to it in its attractions, it quits one body to unite with another; or rather, the bodies to which caloric is united, having a stronger attraction for other bodies than that which they have for caloric, suffer this principle to escape, in order to unite with those other bodies. There is not a single fact in chemistry which does not exhibit one or the other of these phenomena, relative to the disengagement or fixation of caloric, or rather to the disengagement or fixation of elastic fluids; and sometimes both the one and the other of these phenomena at once. We see from this simple theory, which is nothing else but the enunciation of facts, that all elastic fluids ought to be distinguished by two names; the first of which expresses their aeriform combination with caloric; such are the

generic names of air or gas (the former, when these fluids are proper for combustion and respiration; and the other, when they cannot serve that purpose); and the second is specific, and denotes the particular base of each gas or elastic fluid. We see, likewise, that in order to present a general recapitulation of all the facts of chemistry, it is necessary to take a review of the elastic fluids which are either produced and disengaged, or fixed and absorbed in the various phenomena of this science.

All the elastic fluids, whose properties require to be here attended to, may be divided into four classes.

1st CLASS.

Elastic fluids capable of maintaining combustion and respiration.

Species I. Vital air.

II. Atmospheric air.

2d CLASS.

Elastic fluids which are incapable of maintaining combustion or respiration, and are not of a saline nature, nor soluble in water.

Species III. Azotic gas.

IV. Nitrous gas.

3d CLASS.

Elastic fluids which are incapable of maintaining combustion or respiration, which are of a saline nature, and soluble in water.

Species V. Carbonic acid gas.

VI. Sulphureous acid gas.

VII. Fluoric acid gas.

VIII. Muriatic acid gas.

IX. Oxygenated muriatic acid gas.

X. Ammoniacal gas.

4th CLASS.

Elastic fluids incapable of maintaining combustion or respiration, and which are inflammable.

Species XI. Hydrogen gas.

XII. Sulphurated hydrogen gas.

XIII. Phosphorated hydrogen gas.

XIV. Hydrogen gas mixed with azotic gas.

XV. Hydrogen gas mixed with carbonic acid gas.

XVI. Carbonaceous hydrogen gas.

Concerning the Nature and principal properties of these several Kinds of Elastic Fluids.

1. *Vital air*, or oxygen gas, called by its discoverer, Dr. Priestley, *dephlogisticated air*, and by some other English writers *empyrean air*, or the *principium forbile*, is now obtained from a variety of substances. *Precipitate per se*, or oxyd of mercury, *red precipitate* or oxyd of mercury prepared by the nitric acid, the precipitates of different mercurial salts by caustic alkalis, red oxyd of lead moistened with nitric acid, nitrats with alkaline or earthy bases, nitrat of silver, oxyd of manganese, either alone or moistened with sulphuric acid, oxygenated muriatic acid, super-oxygenated muriat of potash, acetit of mercury, arseniat of zink afford this fluid in various quantities by the action of light and heat, its disengagement being manifestly owing to the simultaneous action of these two agents. It does not exist entire in all these bodies, as in fact they contain nothing more than its solid base, which is melted by the caloric and light, and put into the state of elastic fluidity; the metallic oxyds being revived in proportion as this fluid is disengaged. It is likewise obtained from the leaves of plants immersed in water impregnated with the carbonic acid, and exposed to the sun's rays.

Vital air is often mixed with a small quantity of azotic gas. This fluid, when obtained from oxyd of mercury, oxyd of manganese, super-oxygenated muriat of potash, or by means of the leaves of plants, plunged in water, and exposed to the solar rays, does not contain azotic gas.

Vital air is rather heavier than the air of the atmosphere. It is the only elastic fluid capable of maintaining combustion, and is three times as effectual as atmospheric air in this process. That is to say, a body which requires four cubic feet of atmospheric air to be completely burned, will require no more

than one cubit foot of vital air for the same purpose. Combustion in this last fluid is made with an excessive heat and light: these two phenomena arise from the rapid separation of fire, which quits the base of this air, in proportion as the base itself becomes fixed in the bodies which are burned. There are instances of combustions effected by this air, wherein heat only, and not light, is disengaged. This takes place when the disengagement is made slowly and successively. Vital air is equally effectual in the process of respiration of animals, and it affords to their blood that quantity of caloric, which raises its temperature above that of the medium they inhabit.

The base of vital air combined with carbon, with sulphur, with phosphorus, with azot, with arsenic, &c. constitutes the carbonic, the sulphuric, the phosphoric, the nitric, the arsenic acids, &c. From this property it is that we have called its base oxygen, or the acidifying principle. It must be observed, first, that these combinations do not always take place when the combustible bodies are plunged cold into vital air, and that it is necessary at least for their rapid production, that the temperature be more or less elevated; secondly, that this base, or oxygen, enters in different proportions into the compounds, in order to produce a complete saturation; and that the compounds are different according to the quantities of the component parts; thirdly, that its affinity for these different substances is not the same in all, so that phosphorous takes the oxygen from the arsenic acid, and carbon takes it from the phosphoric acid, &c. Fourthly, that when this principle passes from one of the bodies, in which it was fixed and unelastic, into another, a kind of slow combustion takes place, which is not attended with light or heat, because the oxygen is in the state of privation of the greatest part of these two principles.

Oxygen united to hydrogen, constitutes water, and compounded with metals forms metallic oxyds; charcoal decomposes water and metallic oxyds at an elevated temperature, because it has a greater affinity with the oxygen, than the latter has with hydrogen and metals.

Vital air discolours vegetable and animal substances: absorbed by fixed oils, it thickens them, and reduces them to a state resembling that of wax. Combined with the muriatic

and the acetous acids, it forms oxygenated muriatic acid, and acetic acid, or radical vinegar.

The heat of the sun, when powerful, disengages oxygen in the state of vital air from many of its combinations; such as the oxyds of mercury, silver and gold, nitric acid, oxygenated muriatic acid, &c.

II. *Atmospheric or common air* is a compound of the preceding vital air with azotic gas. One hundred parts of atmospheric air, contain nearly 73 parts of azotic gas and 27 parts of vital air. From this is easily understood the reason why only a fourth part of any quantity of atmospheric air is consumed during combustion; and why the phenomenon of combustion takes place more slowly, and is accompanied with less heat and light than in pure vital air. But we must observe, that there is not perhaps a single instance of combustion, in which the 27 parts of vital air contained in the common air of the atmosphere, are entirely absorbed and fixed in the combustible body; and that accordingly the aeriform residue of atmospheric air remaining after combustion, is scarce ever pure azotic gas, not even when the burnt body remains in a fixed and solid state, without mixing with the elastic fluid. The azotic gas must therefore be still more impure, when the body, burnt under a bell-glass filled with atmospheric air, affords a residue in a permanent aeriform state, as is the case with charcoal, and all organic matters containing it.

There are a number of bodies which alter atmospheric air, by absorbing its vital air. But we know of none that renew and purify it except the leaves of vegetables; when exposed to the rays of the sun they disengage vital air from carbonic acid and water, in consequence of the decomposition which they produce.

III. *Azotic gas*, which exists in the atmosphere in a large proportion, has been so named, because it very soon kills animals, and extinguishes combustion; and because it appears to be in its nature directly opposite to vital air. Dr. Priestley called this elastic fluid *phlogisticated air*; because, according to his opinion, it derived its noxious properties from phlogiston, disengaged out of burning bodies, or odorous matters; in a word, from all those operations of nature and art, which he

has called *phlogisticating processes*. But it is at present proved that this fluid exists ready formed in the atmosphere, and is only separated in proportion as the vital air is absorbed. Modern philosophers have made more important discoveries concerning this, than concerning any other elastic fluid. There are several ways of obtaining pure azotic gas. That which is most generally employed, is the exposing of a quantity of liquid sulphure of potash to a given quantity of atmospheric air under bell-glasses: the vital air is gradually absorbed: and when the absorption is complete, the azotic gas remains pure. We owe this process to Scheele. Berthollet has discovered, that it may also be obtained by treating muscular flesh, or the fibrous part of the blood, after having washed it well, with diluted nitric acid, in an apparatus suitable for collecting the gas: but these animal matters, when used for this purpose, must be perfectly fresh; if altered, they afford, together with the azotic gas, a mixture of carbonic acid. I myself have discovered, that the swimming-bladder of the carp, which Dr. Priestley had before observed to contain noxious air, are full of this fluid, which may be obtained simply by breaking them under bell-glasses filled with water.

Azotic gas is lighter than atmospherical air. It instantly extinguishes burning tapers; and acts with great rapidity and energy in destroying the life of animals immersed in it. When mixed with vital air, in the proportion of 73 to 27, it forms an artificial atmospherical air; in a larger proportion, it forms an air noxious to animals. Neither water, nor earths, nor acids, are known to act upon this gas: It appears, however, that it is capable of being absorbed by the nitric acid, which renders it ruddy. Mr. Cavendish has discovered, that three parts of azotic gas, mixed in glasses with seven parts of vital air, and exposed to the action of the electric spark, are by degrees condensed, and form the nitric acid: hence the theory of the formation of this acid in the atmosphere. Berthollet has found, that ammoniac is decomposed by hot nitric acid, by oxygenated muriatic acid, and in the detonation of fulminating gold. He has discovered, that ammoniac consists of five parts by weight of azot, and one part of hydrogen. He has also observed, that animal matters contain a great deal of azot,

that the ammoniac obtained from them by the action of fire and putrefaction is formed by the union of that azot with hydrogen; and that plants, which afford this same salt by distillation, afford it in consequence of their containing azot, and therefore well deserve the name of *animal plants*, which has been given them by some chemists. I have since satisfied myself by experiment, 1. That of all animal matters, the fibrous part is that which affords the most azotic gas by nitric acid. 2. That after putrefaction, it contains no more azot, but affords then a large quantity of ammoniac. 3. That several vegetable matters, in particular the gluten of farina, elastic gum, green fecula, and ligneous matter, furnish azotic gas by the action of the nitric acid.

These remarkable qualities of azotic gas are particularly worth the attention of the physician. They contribute to explain the difference between animal and vegetable matters, the formation of ammoniac, putrefaction, and the production of the nitric acid from putrid animal matters.

As this elastic fluid has been by some people confounded with carbonic acid, it is to be remembered, that azotic gas has no sensible taste, that it is much lighter than that aeriform acid, and neither reddens tincture of turnsole, nor precipitates lime water.

IV. *Nitrous gas* was in some measure known to Hales; but Dr. Priestley is properly the discoverer of it. This elastic fluid is disengaged from nitric acid by the action of a great number of combustible bodies, especially metals, oils, mucilages, and alcohol. It extinguishes lights; it destroys animals; it is neither acid nor alkaline; it is not liable to be altered by pure water. By combination with vital air, it re-produces nitric acid; being itself nothing but nitric acid, deprived of a part of its oxygen, and consequently a compound of azot and oxygen, but containing more azot and less oxygen than the nitric acid. Hence the variations in proportions of this gas depending on the more or less complete decomposition of the nitric acid, by the combustible bodies employed to decompose it; and hence the uncertainty of its eudiometrical effects. From this we understand, why, in several instances, especially when, in order to obtain nitrous gas, we use a body very greedy of oxygen, and requiring a considerable quantity of oxygen to saturate it, the nitrous gas obtained, contains naked azotic gas;

and even, sometimes, nothing is obtained but azotic gas. This nitrous gas, which is formed of azot and oxygen, contains a larger proportion of the oxygen than atmospheric air does. Of this a proof is obtained by decomposing it by an alkaline sulphure in solution. A solution of sulphure of potash, when put into a glass filled with nitrous gas, immediately absorbs a part of the gas: in a short time the gas is no longer reddened by the contact of air, and becomes fit for maintaining combustion, even better than atmospheric air. It is actually converted into air, somewhat purer than the air of the atmosphere, or containing a larger proportion of vital air than atmospheric air usually contains: but if the action of the sulphur be still continued, the whole of the vital air is soon absorbed, and what remains is nothing but azotic gas. We may farther observe, that nitrous gas communicates to flame a green colour, before extinguishing it; and that in many instances, this colour is produced by compounds, of which azot forms a part.

These leading properties of nitrous gas, particularly the rapidity of its combination with vital air, show, that it bears an analogy to combustible bodies; and it has been observed by Macquer, that the artificial formation of nitrous acid by the mixture of these two gases is a species of combustion; but as it is not accompanied with flame, I have not ventured to rank nitrous gas among the inflammable gases. It differs from atmospheric air in the proportion of its principles, and in their state of compression. In nitrous gas, the oxygen and azot are deprived of all that quantity of caloric and light which they contain in the atmosphere. The oxygen, however, still retains enough of both these principles to occasion a combustion, with flame, of several combustible bodies, when immersed in it, as pyrophorus, &c.

V. *Carbonic acid gas* is the first elastic fluid which was known. Dr. Black, who discovered its presence in chalk and alkalis, has proved, at the same time that the effervescent property, the mildness and crystallizability of these substances, were owing to this elastic fluid; that when deprived of it, alkaline substances became acrid, caustic, non-effervescent, &c. This gas exists in the air, of which it forms nearly the $\frac{1}{100}$ part; in acidulous waters, in certain subterraneous cavities,

such as the Grotto del Cano, &c. ; its weight is nearly double that of the air of the atmosphere ; it has a penetrating smell, and a sour taste ; it extinguishes bodies in a state of inflammation, kills animals, reddens the tincture of turnsole, precipitates lime water, renders chalk soluble in water, forms, with alkaline matters, carbonats, or a kind of crystallizable neutral salts, in which the alkaline properties are still perceptible, on account of the weakness of the acid. This acid gas, which is greatly concerned in the phenomena of nature and art, is a compound of carbon and oxygen ; the first in the proportion of twenty-eight parts in the hundred, and the latter seventy-two. As carbon appears to be, of all known substances, that which has the strongest possible attraction for oxygen, the carbonic acid is one of the compounds the most difficultly destroyed, and which is most frequently produced in chemical analyses. It is formed in all cases wherein bodies which contain oxygen are heated with charcoal, as in the reduction of the various metallic oxyds, by means of oils, in charcoal itself, &c. by the decomposition of organic matters, which contain charcoal and water, &c.

VI. *The sulphureous acid gas* which is obtained, whether by burning sulphur very slowly, or by depriving the sulphuric acid of part of its oxygen, is a compound of sulphur and oxygen, in which this last principle is less abundant than in the sulphuric acid : this gas has the acrid and penetrating smell of sulphur, and a very sour taste ; it extinguishes combustible substances which are ignited, and it destroys animals ; it may be condensed into a liquid by extreme cold, as Monge has discovered ; it reddens and discolours most vegetable blues ; it unites to water and ice, which it melts by virtue of the heat which this gas disengages during the time of its fixation : it gradually absorbs the atmospheric oxygen, and passes to the state of sulphuric acid.

VII. *The fluoric acid gas* is disengaged from the native fluat of lime, or *vitreous spar*, by the sulphuric acid ; its taste and smell are very strong ; it dissolves siliceous earth, and holds it suspended in the aeriform and invisible state. The contact of water, by fixing it, separates a portion of this earth ; alkali separates it entirely. Its nature is not known ; and if this acid, like many other mineral acids, be a compound of a sim-

ple acidifiable base with oxygen, this acidifiable radical must have a very strong attraction for oxygen, since charcoal does not deprive it of it.

VIII. The *muriatic acid gas* is nothing but the muriatic acid, disengaged from water, and melted into an elastic fluid by caloric. Its smell, which is lively and suffocating; its taste, which is very strong; its solubility in cold water, which absorbs it very readily, and separates the heat, which kept it melted; the peculiar neutral salts it forms with earthy and alkaline bases; the white vapour which is perceived when it comes in contact with the water of the atmosphere, are its characteristic properties. The intimate nature of its composition is not known; its acidifiable basis doubtless adheres very strongly to its oxygen, since its principles have not yet been separated. We shall proceed to show that this acid has even the property of depriving many substances of the oxygen with which they are saturated.

IX. *Oxygenated muriatic acid gas* is disengaged with great facility during the reciprocal action of native oxyd of manganese and muriatic acid. This peculiar gas is known to be produced by the transition of oxygen from the manganese into the muriatic acid. This gas always retains a colouring part, of a greenish yellow: its smell is strong and pungent: it is not acid: it weakens and reddens the flame of a taper, but does not extinguish it: it is very quickly fatal to animals: it discolours stuffs, tincture of turnsole, and flowers, rendering them all white: it likewise discolours and whitens yellow wax, &c. it decomposes ammoniac, which may now be used as a preservative against its noxious effects; the azotic gas of the ammoniac is separated in proportion as the oxygen of the muriatic gas combines with its hydrogen to form water: it thickens fixed oils; it oxydates metals; and even mercury and gold are subject to its influence: the greater part of metallic substances, when reduced to a powder, and thrown into a bell-glass containing oxygenated muriatic acid, burn in it with a brilliant flame: it is soluble in water, and communicates to that fluid all its properties: the contact of light by degrees decomposes it, and reduces it into the state of pure muriatic acid.

The formation of oxygenated muriatic acid, and oxygenated

muriatic acid gas, is one of the most remarkable discoveries of modern chemistry. This discovery shows, that the relations of muriatic acid to combustible bodies are directly contrary to those of the other acids. All the other acids appear to be decomposable by most of the metals, which have in general a stronger affinity with oxygen than the combustible or radical bases of those acids have. The muriatic acid, on the contrary, is not decomposed by any metal: none of them detaches its oxygen; and in consequence of this, it scarce acts on any of the metals. Its base, which is still unknown, is not only intimately connected with the acidifying principle, but even detaches that principle from several other metallic oxyds, such as those of mercury, lead, iron, &c. when saturated, it is no longer acid, as excess of oxygen destroys its acidity. The case is directly contrary with many other combustible bodies. This excess of oxygen enables it to act upon metals, on which, in its ordinary state, it produces no change; such particularly are antimony, mercury, silver, and gold. In proportion as these metals rob it of this excess of oxygen, they are by degrees burned, and dissolved in the muriatic acid, which returns itself into its original state. These oxydations and solutions of metals, by the oxygenated muriatic acid are accomplished without effervescence, in the same manner as a salt is dissolved in water; for the metal takes up the superabundant oxygen of the liquid acid quietly, and without being obliged to disengage it from a combustible base. Oxygenated muriatic acid likewise dissolves metallic oxyds, and thereby forms oxygenated muriats, very different in their nature from simple muriats. The most striking and most remarkable of these differences appears in the combinations of this acid with oxyd of mercury. With oxygenated muriatic acid, oxyd of mercury forms *corrosive sublimate*: with simple muriatic acid, the same oxyd forms *mild mercury*. The differences between these two salts are therefore owing to the greater proportion of oxygen in the former than in the latter salt. The singular properties of the oxygenated muriatic acid render it extremely useful in several of the arts: some of which indeed owe their origin to it, as the bleaching of linen and cotton, discovered by Berthollet.

X. *Ammoniacal gas*, discovered by Dr. Priestley, is disengaged

by heat from liquid ammoniac, and, with still more rapidity, from a mixture of ammoniacal muriat, or common sal-ammoniac, with quicklime. This elastic fluid, when collected in glasses over mercury, is found to be a little heavier than atmospheric air. The degree of cold or pressure at which it loses its aeriform fluidity, is still undetermined. It combines with water, giving out, while the combination takes place, a good deal of heat: it melts ice: it renders syrup of violets, as well as blue and red flowers, green: it combines rapidly with carbonic, sulphureous, and muriatic acid gases; these combinations produce much heat: as this heat is disengaged from the two elastic fluids, these become solid while the two combinations are forming.

Ammoniacal gas is speedily decomposed by the contact of oxygenated muriatic acid gas: this decomposition is accompanied by heat and light: a quantity of water, charged with muriatic acid, is formed, and there is a residue of azotic gas. This experiment, as well as several others which have been already mentioned, proves that ammoniac consists of hydrogen and azot. The composition of ammoniacal copper, and of *fulminating gold* and *silver*, which afford, by the action of fire, water, reduced metal, and azotic gas, is another proof that ammoniacal gas consists of these principles; indeed the hydrogen, the principle of this alkali, having a stronger affinity for oxygen than either copper, gold, or silver, detaches it from the oxyds of these metals, and leaving its azot free to be disengaged in a gaseous state, forms water with the oxygen. The phenomena of this decomposition of ammoniac by oxyds vary much from that which oxyd of copper effects slowly, and with the assistance of a strong heat, to the amazing rapidity with which ammoniacal oxyd of silver is reduced, when it detonates by simple contact. The diversity of these phenomena is owing to the various affinities of oxygen with the different metals.

Oxyds of zink and iron, which in their metallic state decompose water, have not the same power over ammoniac; because these metals have a greater affinity with oxygen, than oxygen has with hydrogen. Hence it is easy to conceive, 1. How ammoniac is produced by the putrefaction of animal substances, and during the decomposition of water and of nitric acid by

some metals, as tin. 2. How, in opposite circumstances, when ammoniac is decomposed by metallic oxyds, the nitric acid comes to be formed.

XI. *Pure hydrogen gas*, universally known by the improper name of *inflammable air*, is the lightest of all aeriform fluids: When very pure, it is thirteen or fourteen times lighter than atmospherical air. It extinguishes burning bodies: it kills animals: it is kindled by the contact of the electric spark, or of any inflamed combustible body: it burns with a bright flame. Fifteen parts of this gas absorb, in burning, eighty-five of vital air; and by that combustion, an hundred parts of very pure water are formed if the elastic fluids be pure. Water is therefore a compound of these two bodies, deprived of a great part of the caloric, which is necessary to maintain them in the state of elastic fluidity. All substances having a stronger affinity with any one of these two principles, than that by which their union is maintained, decompose this fluid. Thus iron, zink, coal, and oils, decompose water, and separate hydrogen from it into a gaseous state; because they have a stronger affinity with the base of vital air or oxygen than it has with hydrogen. From this it is clear, that hydrogen gas ought not to decompose carbonic acid, or the oxyds of zink and iron: On the contrary, sulphur, and such metals as do not decompose water, give up the oxygen which they contain, in the state of sulphuric acid, and of metallic oxyds, to hydrogen gas which reduces the former to the state of pure sulphur, and the latter to the state of metals. This decomposition of water by iron and zink, is the cause of the production of the hydrogen gas evolved during the solution of these two metals by the sulphuric, the muriatic, the carbonic, or the acetous acids.

The leaves of vegetables, on the contrary, appear to possess the property of absorbing the hydrogen from water, and disengaging its oxygen in the state of pure air. Light appears to contribute greatly to this decomposition; since, without the contact of light, it is not effected. It seems to serve for the purpose of melting the oxygen, and thus forming it into vital air; in proportion as the oxygen is disengaged, the hydrogen becomes fixed in the vegetable, and serves, no doubt, for the production of oil. We begin to perceive that hydrogen com-

bines with carbon and a small proportion of oxygen to form the oil of vegetables ; and that these again decompose carbonic acid, together with water, to absorb the carbon of the first, and the hydrogen of the last of these compounds. Hydrogen, or the base of hydrogen gas, forms ammoniac, by combination with azot, or the base of azotic gas. Berthollet, by analysing that salt, has shown this to be its composition : But we have not yet been able to form ammoniac by the immediate combination of these two principles.

We have never yet been able to separate the matter of heat or caloric combined in hydrogen gas, to which that gas owes its elastic fluidity, without fixing the hydrogen in some other compound ; and therefore, we are still unacquainted with hydrogen or the base of this elastic fluid in an insulated state. The degree of pressure or cold necessary to effect this separation, must be such as we have not yet learned to apply : Every thing, indeed, concurs to show, that either the one or the other must be in an extreme degree.

It is to the sudden disengagement, and the rapid inflammation of hydrogen gas, that all the fulminations and detonations are owing, which are observed in chemistry. The instantaneous recombination of water is almost invariably the consequence of these detonations.

Hydrogen gas performs an important part in the phenomena of nature. A great quantity of it is produced and disengaged in mines : It there reduces and colours various metallic oxyds : it rises in the atmosphere, is carried about by the winds, and kindled by the electric spark : accordingly, it acts the part of thunder ; and immediately upon its detonation, a quantity of water is reformed, which streams down upon the earth.

The inflammation of this gas by the electric spark, is one of the most remarkable phenomena in nature, and one of those of which the cause is least known. We are equally at a loss to explain, how the electric spark comes to be capable of fixing a mixture of vital air and azotic gas into nitric acid.

XII. Sulphurated hydrogenous gas, or *hepatic gas*, has been very well distinguished from the other inflammable gases by Bergman. It is obtained from solid alkaline sulphures, or *livers of sulphur*, by decomposing them with acids in a pneuma-

to-chemical apparatus. This aeriform fluid has a very fetid smell; it kills animals: it renders syrup of violets green: vital air precipitates sulphur from it; it is kindled by the electric spark, and by the contact of burning bodies: it burns with a reddish blue flame; and, as it burns, deposits sulphur on the sides of the vessel containing it: the ruddy nitrous acid, the sulphureous acid, and the oxygenated muriatic acid decompose it, destroy its elastic fluidity, and separate the sulphur. It combines with water, and the solution is decomposed by the action of air, and by the same acids as the gas itself: sulphurated hydrogenous gas colours and reduces oxyds of lead, bismuth, &c.; it precipitates solutions of metals. Some metals, particularly mercury and silver, separate the sulphur; accordingly, when passed through glasses containing mercury, a great part of it is decomposed.

All these phenomena agree in showing, that this gas contains sulphur in a very attenuated state. Gengembre, by an analysis, has discovered that it consists of hydrogen gas and sulphur: it is to the solution or suspension of sulphur, it owes its distinguishing characteristics. The sulphur, however much attenuated, does not burn at the same time with the hydrogen gas, but is in part deposited during the combustion of the gas: The cause of this phenomenon is, that hydrogen gas does not require so high a temperature to be inflamed by the contact of bodies in a state of ignition.

It is sulphurated hydrogenous gas which mineralizes sulphureous waters. On this account, the common acids never precipitate sulphur from those waters; while the nitrous acid, the sulphureous acid, and the oxygenated muriatic acid, in which the oxygen is not very intimately combined, separate the sulphur by absorbing the hydrogen. If too much of any of these acids be employed, especially of the oxygenated muriatic acid, the sulphur of this gas will be burned, and converted into sulphuric acid; and then no precipitate will appear. This phenomenon takes place particularly in sulphureous waters, in which the precipitation of sulphur by these acids, requires that they should be used with caution.

Our knowledge of sulphurated hydrogenous gas throws much light upon several things concerning sulphur, which we were

before unable to account for. 1. We know now, why solid sulphures, recently prepared, are without smell; and why they become so strongly fetid, when moistened: 2. It appears that water, though not decomposable by sulphur alone, is easily decomposed by the conjoined action of sulphur and alkaline matters: 3. We understand fully, how alkaline sulphures come to be decomposed by the air, and by several metallic oxyds, especially by the oxyds of metals which do not decompose water: 4. The theory of sulphureous mineral waters is now easy to explain; as well as the history of their decomposition by air and metallic solutions, and the difficulties which were formerly found in all attempts to detect the sulphur by simple acids, while it was not suspected to exist in those waters in any other state but that of a sulphure or *hepar*.

XIII. *Phosphorated hydrogenous gas* was discovered by Gengembre, who called it at the first *phosphoric gas*. He obtained it, by boiling a lixivium of caustic potash with half its weight of phosphorus, and by receiving the elastic fluid that was disengaged, into glasses containing mercury. This gas is very fetid, it kills animals. It kindles by the mere contact of air, producing as it takes fire, a faint explosion. The solid phosphoric acid which it affords when burning, forms a sort of *corona* in the air; this figure is produced only in an atmosphere that is tranquil, and its diameter increases as it ascends. When mixed with vital air under glasses, phosphorated hydrogen gas burns with the greatest rapidity, and produces such heat and dilatation that the glasses burst if they be not very thick, or if the proportions of the mixture be too large.

Gengembre has shown, that this new gas is a solution of phosphorus in hydrogen gas. It bears a considerable resemblance to sulphurated hydrogen gas; and differs from it in nothing but the nature of the combustible body suspended in the hydrogen gas. As phosphorus is much more combustible than sulphur, phosphorated hydrogen gas kindles in the air: the phosphorus is first kindled, and communicates the inflammation to the hydrogen gas, heated by the combustion. In sulphurated hydrogen gas, on the contrary, the hydrogen gas is kindled only by the contact of some body in ignition; and the sulphur not being sufficiently heated, is separated without being burned.

XIV. *Hydrogen gas*, mixed with azotic gas, is the elastic fluid denominated *inflammable air of marshes* by Volta. It is produced by the putrefaction of some vegetable matters, and of all animal substances. It is disengaged from waters in marshes, ponds, houses of office, and in all places where there are animal matters putrefying in water; it is obtained also from the distillation of several animal substances. It either accompanies, precedes, or follows the formation of ammoniac which takes place in putrefaction. I think it a simple uncombined mixture; for, were they actually combined, the result would be ammoniac from which it differs, 1. In the elastic state of the two fluids of which it consists: 2. In the proportions of those elastic fluids, which vary in this mixed gas, while the quantity of their bases, combined in ammoniac, are always the same. We are indebted for an accurate knowledge of this gas to Berthollet. In the year 1778 and 1779, I examined the *inflammable gas of marshes*, and discovered in it the presence of carbonic acid: but in several of those gases, collected in different parts of the neighbourhood of Paris, I found a mixture, the nature of which I did not properly distinguish; although I asserted, as may be seen in the 164th page of the collection of my Memoirs in 8vo, that it is sometimes accompanied, or even has its place supplied by *phlogisticated gas*, which, as I have elsewhere shown, is the same with what we at present call azotic gas. These were merely vague assertions at the time when I inserted them in my Memoirs: but Berthollet has since communicated to them a precision which induces me to distinguish this gas by the peculiar names which have been formerly explained.

Hydrogen gas, mixed with azotic gas, burns with a blue flame. It detonates difficultly with vital air. When detonated in Volta's eudiometer, some drops of water, and a residue more or less pure of azotic gas are produced.

XV. I distinguish, by the title of *hydrogen gas mixed with carbonic acid*, that gas which is obtained by distillation from many vegetable matters, particularly from tartar, and all tartareous salts; from acetous salts; from hard wood; from charcoal burned with the help of water; from pit coal, &c.

It burns with difficulty, though without its ceasing to be

combustible, three fourths of its bulk may form carbonic acid. This acid is separated from it, and the hydrogen gas purified by lime water and caustic alkalis. It is a simple mixture, without combination. Indeed hydrogen gas is not capable of decomposing carbonic acid; since carbon decomposes water, having a stronger affinity than hydrogen for its oxygen.

XVI. *Lastly*, It is known that carbon, though very much fixed in close vessels, and in our common fires, is capable of being reduced to vapour, and dissolved in elastic fluids, in a very high temperature. Hydrogen gas in particular possesses the property of disengaging carbon, and maintaining it in suspension; it frequently therefore carries it with it, in assuming the elastic fluid form. It is this mixed gas that is disengaged, when cast iron and steel are dissolved in diluted sulphuric acid; in consequence of the former having absorbed carbonaceous matter in the high furnaces, and the latter in its cementation. It even appears that carbon may be directly dissolved in hydrogen gas, by directing the rays of the sun collected in the focus of a mirror, upon a bit of charcoal placed on mercury in the bottom of a glass filled with this gas. This fluid burns with a blue flame; and gives out during its combustion, small white or reddish sparks. The existence of carbon dissolved this gas, is proved by its gravity, and by its combustion in vital air, which produces carbonic acid. It likewise appears, that carbon communicates to hydrogen gas its well-known fetid smell, or at least it renders that smell stronger. *Lastly*, Carbon modifies the effects of this gas, and changes the results of its combinations. Thus, a mixed gas, formed by the solution of carbon in azotic gas, seems to be the colouring matter of Prussian blue. But we are not yet acquainted with all the compounds into which carbon enters: and the same is to be said of the various mixtures of all the gases with one another, which certainly take place in a great many combinations, but of which chemistry has not yet estimated the effects.

Of the Application of the Facts which have been collected, concerning the Nature and Properties of Elastic Fluids, to the great Chemical Phenomena produced by Nature and Art.

It is now demonstrated that there is scarcely a single phenomenon in chemistry in which some elastic fluid is not either disengaged or fixed; nay, sometimes both the disengagement and fixation of elastic fluids take place on the same occasion: and the discoveries of the moderns have proved, that the manner in which such phenomena were formerly accounted for, neither explained the causes, nor gave a just view of the effects. The perspicuity which these discoveries have introduced is a sufficient proof of their importance in natural philosophy.

On comparing the numerous facts which constitute the whole of chemical knowledge, it appears that they may be reduced to a few general classes, containing them all under distinct heads. Such an arrangement is the more necessary, as it shows the connections of those facts; and must form, of consequence, the true elements of the science of chemistry. But this last object cannot be attained, till all the general phenomena be explained: and as we are still unable to account for the number of these, as I am about to show, this elementary method of treating the whole of chemistry in general propositions, is to be considered in no other light than as a proposal, the importance and utility of which render it worthy the attention of philosophers.

It is with a view to contribute in part to the carrying of this project into execution, or at least to show that it is not impossible, that I have attempted to reduce all the facts, and the whole theory of chemistry, under fourteen leading phenomena, comprehending the various changes which natural bodies are liable to suffer from the action of the chemical affinities. In order to proceed regularly from simple to compound, in explaining these phenomena, I arrange them in the following order.

1. The absorption or disengagement of caloric, and the production or diminution of heat, with the effects of both.
2. The influence of air in combustion, and the general nature of combustible bodies.
3. The effects of light on bodies.

4. The decomposition and the recomposition of water.
5. The production and the decomposition of earths.
6. The formation and the decomposition of alkalis.
7. Acidification ; the formation and decomposition of acids ; the nature of these salts, their differences, their analogies, their action on most bodies, &c.
8. The combinations of acids with earths and alkalis.
9. The oxydation and the reduction of metals.
10. The solution of metals by acids.
11. The formation of the immediate principles of vegetables by vegetation.
12. The several species of fermentation.
13. The formation of animal matters by the life of animals.
14. The putrefaction and decomposition of animal matters.

Let us briefly consider each of these phenomena, and explain their essential relations with the properties of elastic fluids.

I. *The production of heat*, or disengagement of caloric, is owing either to the force of pressure, which disengages it from bodies in which it is contained, or to combination, which disengages it in like manner. It is to be observed, that this phenomenon takes place more especially when an elastic fluid is fixed in any body ; because, as we have already seen, this aeriform state supposes the presence of much combined caloric. It is also to be observed, that as every different body contains a different quantity of caloric, or, in other words, different bodies have different capacities of caloric, therefore pressure or combination must produce, from different bodies, very different quantities of this substance. For which reason, this phenomenon, which accompanies a great part of the operations of chemistry, should be estimated with the utmost care in experimental researches. Similar to this is the manner in which the apparent destruction of heat or *absorption of caloric* takes place, which is likewise very often observed in chemical processes. It is always connected with an increase of the bulk of bodies, and with their then acquiring a greater capacity for the reception of caloric. Both of these phenomena, therefore, may be estimated mechanically, or merely by observing how the

particles of bodies are compressed together, or removed from each other. But in order to form a more just idea of it, we must add to this mechanical cause, the consideration of the chemical attraction or particular affinity of caloric for different bodies. The moderns have made a great many discoveries respecting the influence of caloric in combinations and decompositions.

II. Combustion is one of the most important phenomena in nature. We may distinguish two distinct classes of combustions; those which take place in the air, and those which take place apparently without the contact of vital air, but in substances containing its base.

Combustions effected by the contact of air, are, as has been already said, combinations of the combustible body with the base of vital air or oxygen. In proportion as these combinations take place, the matter of light and caloric are separated from the oxygen in a greater or less quantity, and appear in the form of light and sensible heat. There are some combustible bodies which, by disengaging these fluids slowly from vital air, afford only little heat when they burn: others, again, disengage these principles rapidly, and cause them to appear in the form of sparkling light, and glowing heat. By communicating more or less oscillation to this light, they gave it different shades of colouring; if, with Euler, we may consider different coloured rays of light as being all the same matter, only actuated by different oscillations, similar to the vibrations of sound. In certain combustions effected by air, the combustible bodies have so great an affinity to the base of the elastic fluid, that they attract it with the utmost facility; others require, in order to their combination with oxygen, a temperature sometimes exceedingly high, which appears to promote the attraction of the combustible body for that base. This theory accounts for the increase of the weight of a burnt body; the change of its state; the impurity of atmospheric air after combustion, since the proportion of azotic gas then becomes much larger, and the diversity of the phenomena, such as flame, heat, and rarefaction, which accompany every species of combustion effected in the atmosphere.

The second class of combustions is generally effected in close vessels. It consists in general in the transition of oxygen, either more or less solid, out of a body already burnt, into an unburnt body. It depends upon the different elective attractions of this principle for different combustible bases. To this class belong the oxydation of metals by acids, the reduction of metallic oxyds by carbon, the combustion of sulphur, phosphorus, carbon, and carbure of iron by nitric acid, the combustion of hydrogen, the principle of ammoniac, by the oxygenated muriatic acid, &c. &c. In all these instances, oxygen passes out of one body into another; and as it was not melted into an elastic fluid by caloric and light, these combustions generally take place without flame. We may observe, that in these instances of combustion, which may be considered as *silent*, and called *oxygenations*, the property of combustibility is not lost, but only transferred from the body which absorbs the oxygen to that which loses it. We may likewise add, that as oxygen is more or less solid, that is, more or less deprived of caloric and light, in the compounds into which it enters, bodies which detach it from these may sometimes absorb it in a state more pure and solid than that in which it before existed: and the disengagement of caloric, and even of light, must then take place. Such is the origin of these two phenomena in detonations by nitre, in the apparent action of nitric acid on sulphur, carbon, phosphorus, the generality of metals, oils, and alcohol.

III. *The effects of light on bodies*, have been hitherto estimated only by their results; their cause has never yet been properly explained. It has been long known to act upon vegetables, to communicate to them colour, and to develop their combustible principles. Scheele observed, that the rays of the sun coloured nitric acid, muriat of silver, mercurial precipitates, &c. It is at present well known, that all these effects are accompanied with the disengagement of a more or less considerable quantity of vital air: light, therefore, acts at the same time with caloric upon these bodies, separates their oxygen, which it melts and causes to pass into the state of elastic fluidity. This effect is very obvious with respect to oxygenated muriatic acid, which by exposure to the rays of the sun, gives out vital air, and re-

passes to the state of ordinary muriatic acid. It is in this manner that light contributes to the decomposition of carbonic acid by the leaves of vegetables. That decomposition is, in truth, owing to a double attraction; 1. The attraction of light and caloric for oxygen, which they tend to disengage in vital air, &c.; 2. That with which vegetable matters act upon carbon, the radical principle of this acid. By the same mechanism, light promotes the decomposition of water by the same organs of vegetables, and contributes to the formation of their oleaginous principle. By attending with more care than has been hitherto done, to the action of light upon many natural bodies, some important discoveries may be made, as I pointed out in the year 1780.

IV. *The formation and the decomposition of water*, depend entirely on the affinities of oxygen, which is one of its principles. Zink, iron, oils, and carbon, are already known to possess the property of separating the principles of water, by absorbing its oxygen, and disengaging its other principle, hydrogen, in the form of hydrogen or inflammable gas. The extreme levity of this gas, accounts for the high temperature requisite to effect this decomposition suddenly. It appears, that the base of this gas, hydrogen, which is commonly either liquid or solid, in the two states in which water is commonly found on the surface of the globe, has a very great capacity for containing caloric or the matter of heat. It even appears, that this base, though combined with oxygen in water, still possesses the property of absorbing a great deal of heat; and that it is this property which renders aqueous vapour lighter than air; in consequence of which it supports a less column of mercury in the barometer. This beautiful discovery of the nature and the decomposition of water, throws much light on the theories of metallic solutions, of the oxydation of various metals by moisture, of the formation of the immediate principles of vegetables, of vinous fermentation, and of putrefaction: And we already see, that almost all chemical theories are referable to, and depend upon the affinities of oxygen. It throws also great light on the phenomena of the atmosphere, the formation of meteors, the laws which nature observes in the successive changes of organic matters, &c. It is particularly worthy observation, that such

substances as do not singly decompose water, effect this decomposition by the assistance of other bodies. Thus sulphur with alkali, tin with nitric acid, &c. decompose water at low temperatures, by means of complex or disposing affinities. Nothing can contribute more to throw light on a great number of the phenomena of nature and the arts, than the knowledge of these predisposing affinities, &c.

V. There are still several important objects with respect to the formation of natural bodies, which the labours of chemists have not explained. One of these is the *formation of earths*. Naturalists have given their opinions concerning the nature of earths: several of them have considered the conversion of *silice* into clay, as a fact sufficiently proved; but that notion is nothing but an ingenious hypothesis, not supported by facts. Chemists have not been able to change either siliceous earth into alumin, or alumin into siliceous earth. Nature, perhaps, produces this conversion; but as we are unacquainted with the means which she employs, we should not venture to guess, when not countenanced by direct experiments. To consider barytes, magnesia, and lime, as compounds of the preceding united with some other bodies, is to advance hypotheses which deserve but very little credit. No chemist has hitherto directed his inquiries to this scope: the necessary *data* are even wanting. The experiments of some moderns on the extraction of pretended metallic reguli, from earths treated with carbon in a violent heat, have afforded only a fallacious result. It appears to be ascertained that all these reguli are but one and the same substance, phosphure of iron, formed from the earth of bones, or a portion of phosphat of lime reduced to phosphorus, and combined with the iron of the carbon.

VI. Nearly similar is the state of our knowledge with respect to the formation of fixed alkalis. The modern ideas of the principles of chemistry, lead us to suspect azot as a principle of these salts. We may perhaps even venture to consider this body, the existence of which in ammoniac, has been fully proved by Berthollet, as a principle common to fixed alkalis and alkaline earths in general, in a word, as the *alkaligenous* principle. Some chemists have thought, that the fixed alkalis are partly decomposed in the many operations of chemistry:

they conceived that they were changed into ammoniac, in the distillation of old soaps, and tartareous and acetous neutral salts. This conversion, if it were proved, would seem to show, that fixed alkalis contain azot, which, by attaching itself to the hydrogen of the oil, forms ammoniac. But these facts have not yet been carefully examined, with respect to the quantities of the fixed alkalis which appear to be decomposed, and that of the ammoniac which is obtained, nor, what is of no less importance, with respect to the residue produced from the fixed alkalis; and we cannot hope to establish our theory upon this fact, till its circumstances be more exactly known. But though these were known, we should still have to inquire into the nature of the other principle or principles of fixed alkalis, and in what manner the radical principle of potash differs from that of soda, &c. A series of researches made with care, with regard to the nature of the two fixed alkalis, would throw much light upon many of the obscure phenomena of chemistry.

VII. *The formation and the decomposition of acids*, is one of the most valuable and best known parts of modern chemistry. We know that they consist all of a base or radical principle, more or less combustible, in combination with oxygen: that the oxygen being the same in them all, is the principle of their acidity; and that the differences among them are owing to the substance or substances combined with the oxygen; which differ in each different acid. We know the bases of the sulphuric, the nitric, the carbonic, the arsenic, the tungstic, the molybdic, and the phosphoric acids: we know them to be sulphur, azot, carbon, arsenic, tungsten, molybdena, and phosphorus. But the acidifiable bases of the muriatic, the fluoric, and the boracic acids in the mineral kingdom, remain still undiscovered; as well as the proportions in which hydrogen and carbon, which seem to form the bases of all the vegetable acids, are united in them.

The decomposition of the acids whose nature is known, is not hard to explain. We know that it must happen, whenever a combustible body, having a stronger affinity with oxygen than oxygen has with the acidifiable base of the acid: And such is the theory of sulphureous and nitrous acid gases by the decomposition of the sulphuric and nitric acids, &c.

The radicals of acids ought also to be distinguished into

simple and compound; sulphur, phosphorus, carbon, &c. are simple radicals. All the vegetable acids have radicals, that are formed of hydrogen and carbon. These last are not decomposed by combustible bodies, because their radicals have more affinity with oxygen than metallic matters, &c. which are generally employed in this decomposition. Thus, of metallic substances, only the metallic acids are soluble in the vegetable acids.

VIII. *The combination of acids with earths and alkalis*, forms the history of neutral salts, and of the affinities or elective attractions of those different matters. It comprehends the examination of the phenomena which take place during their uniting, the taste which they acquire, their form, solution, crystallization, alterations by fire and air, and mutual decompositions. It has been treated of at great length in this work.

IX. *The oxydation and reduction of metals* is also referable to the history of air and oxygen. We know, that what has been called the *calcination* of metals, is a combustion, that it consists in the union and fixation of the base of vital air or oxygen; that metallic *calces* are compounds of metals and oxygen, which we call *oxyds*; that most oxyds are reduced only by giving out their oxygen to some other body having a stronger affinity with it; that carbon, by absorbing oxygen from metallic oxyds in this manner, forms with it the carbonic acid, which is disengaged in such abundance during their reduction; and that there are some metallic oxyds, from which oxygen is separated in the state of vital air, by means of caloric and light, a fact which proves, that this oxygen is combined with different metals, with very different degrees of adhesive force. Thus several metals heated with metallic oxyds, carry off their oxygen, as iron and zink from the oxyd of mercury, tin from the oxyd of copper, &c. But two very important particulars in the history of the oxydation of metals, which have been ascertained by modern experiments, and which throw great light on all the phenomena of metallic matters, are, 1. That every different metal absorbs, in order to its saturation, 2 different quantity of oxygen: 2. That each metal may exist in different states of oxydation, or, combined with different proportions of oxygen, from that which merely begins the oxydation of a

metal, to that by which it is completely accomplished, for instance, from fifteen to forty or more parts of oxygen, to the hundred weight of iron.

The attentive examination of this second fact, leads us to distinguish, in every metallic oxyd, several different states in respect to the quantity of oxygen which it contains. Thus, mercury suffers an incipient oxydation, and is changed into a black powder in a number of circumstances, which have been hitherto considered as effecting only an extreme division of the metal: and particularly when triturated or extinguished with fats, mucilages, syrups, &c. Thus, iron, in the state of *martial ethiops*, is the first oxyd of that metal, in respect of the small quantity of oxygen which it contains, and cold water easily reduces the metal into this state: Lastly, Copper, beginning to be oxydated, or combined with the smallest possible quantity of oxygen, is brown and reddish, a little more oxygen renders it blue; whereas a perfect oxyd of this metal, or one saturated with oxygen, is of a bright green.

This distinction of metallic oxyds, according to their different states of oxydation, or according as they contain different quantities of oxygen, and possess different properties, in consequence of their having been more or less burnt, enables us to explain a great many phenomena, of which chemists were formerly able to give no satisfactory account.

X. *The solution of metals* in different acids, the properties of these solutions, and of the salts which they afford, agree very well with the modern theory, and are much better explained by it, than they formerly were. No solution of a metal in an acid can take place, unless the metal be first oxydated.

Metals are oxydated by the sulphuric acid, either by the acid itself, or by the water with which it is diluted. In the first of these cases, the acid is decomposed, and a quantity of sulphureous acid gas disengaged; in the second, the water is decomposed, and hydrogen gas disengaged. Some metals decompose only the sulphuric acid, without acting upon the water; such as mercury, lead, &c.; and to burn these metals, the acid must be concentrated, and often assisted by heat. Metals which act with more energy in decomposing water than in decomposing sulphuric acid, such as zink and iron, are not so

readily oxydated, unless the acid be diluted, as it is from the water they must derive the necessary oxygen. What proves the certainty of this last fact is, that the sulphuric acid remains undiminished, none of it being decomposed. From these circumstances it is clear, that much more sulphuric acid must be necessary for the solution of a metal which decomposes the acid, than for the solution of a metal which decomposes the water combined with it. In the former case, two different sums of the acid are requisite, one to oxydate the metal, and another to dissolve the metallic oxyd: if only the first sum were mixed with the metal, it would only be oxydated, and the second sum of acid would still be necessary to dissolve the oxyd; in the laboratories, there is frequently occasion to make such an addition. Accurate observation has shown, that metallic oxyds ought to be always in the same degree of oxydation or combination with oxygen, in order that they may be dissolved in the sulphuric acid; and that when they are saturated with the acid, they no longer combine with it. Before this period, they are not soluble in it; beyond it they are precipitated, an event which happens when a sulphuric solution is exposed to too strong a heat, or left for a longer or shorter time exposed to the air. In the first of these operations, the heat promotes the action of the metallic oxyd upon the acid; and it of consequence takes up more oxygen than it contained or needed in order to remain suspended in the acid; in the second instance, it absorbs that principle from the atmosphere, till acquiring more than is necessary to its suspension, the oxyd is precipitated. Such is the theory of sulphuric mother-waters. Solutions of metals by this acid afford crystals only in the former case. All these facts agree in showing, that the metals act first upon their solvents; and that the sulphuric acid does not act upon them till they be oxydated to a certain degree.

Nitric acid is likewise decomposed by most metals. They are oxydated or *calcined* to a certain degree by absorbing its oxygen, with which they have a greater affinity than azot. But as they do not take up all the oxygen of the nitric acid, unless too much of the metal be employed, and the mixture be too much heated, the azot is separated in combination with a portion of oxygen; and this particular combination consti-

tutes nitrous gas. The nitric acid is more liable to decomposition than any other acid: its two component principles not being very intimately united. For this reason, it has always been considered as the chief solvent; and it is owing to the same circumstance, that water is seldom decomposed during the mutual action of metals and the nitric acid, and that a large quantity of water puts a stop to this re-action. Accordingly, solutions of metals in the nitric acid afford only one sort of elastic fluid, nitrous gas, which is sometimes mixed with a little gas azot, especially if the metals employed have a very strong affinity with oxygen, and absorb a great deal of it.

Metals which are soluble in the nitric acid combine, and remain in combination with it, only when they contain a certain quantity of oxygen not equal to their saturation. Many metallic oxyds, therefore, such as those of bismuth, antimony, mercury, tin, and iron, are very easily separated from nitric acid, solely by rest, by heat, or by exposure to the air. As they continue to absorb oxygen from the acid in which they are dissolved, or from the surrounding atmosphere. The quantity of nitric acid must be very large; that it may be sufficient, first, to oxydate the metal; secondly, to dissolve the oxyd. If you employ only what is requisite for the former purpose, you obtain only a dry oxyd; as in the instances of bismuth, zink, tin, and antimony. Metals very greedy of oxygen frequently take up all that exists in the nitric acid, and not having enough for saturation, decompose the water, by absorbing its oxygen. Ammoniac is formed in this case by the union of the azot of the nitric acid with the hydrogen of the water.

The muriatic acid does not act upon any metal without the assistance of water. Wherefore, as there are but few metals which act upon water, there are but few directly soluble in the muriatic acid; and nothing but hydrogen gas is ever disengaged, in the case of solution, by this acid. Every thing concurs to show, that the principles of this acid adhere more obstinately together, than those of any other acid; and from this I am much inclined to think, that the unknown base of the muriatic acid, whatever it be, is the body which has the greatest possible affinity with oxygen, since none of the combustible bodies which detach that principle from the other sub-

stances that contain it, takes it from this acid: but when metallic oxyds are once formed, it dissolves them very readily; it even detaches them from several other acids; and it dissolves them even when fully saturated with oxygen; which the other acids are not capable of doing. The two last of these properties, which are very remarkable, certainly depend on the tendency which the muriatic acid has to absorb an excess of oxygen; a tendency so fully proved by the formation of the oxygenated muriatic acid, &c. When the muriatic acid dissolves metallic oxyds that are too much oxydated to be dissolved by the other acids, it begins by carrying off a portion of the oxygen from the oxyds, and part of the water being disengaged into oxygenated muriatic acid, the rest dissolves the remainder of the oxyd that is less oxydated.

The action of the other acids on metals is not yet sufficiently known, to enable us to explain it so accurately as that of the former. We shall only remark, that metals cannot decompose the carbonic acid; since carbon, the radical principle of that acid, has a stronger affinity with oxygen, than oxygen has with metals; as is proved by the decomposition of metallic oxyds by the carbonaceous principle. It is the same with vegetable acids.

Lastly, The precipitation in the metallic state of metallic oxyds from acids, by other metallic substances, depends entirely on the diversity of the affinities of oxygen with these substances. When copper precipitates oxyd of silver, and iron, oxyd of copper, in the state of silver and copper, the reason of these phenomena is, that copper has a stronger affinity with oxygen than silver, and iron than copper.

XI. We are only beginning to understand the formation of the immediate principles of vegetables. It was long ago observed, that plants grew very well in pure water; and that all their constituent principles were formed with water and atmospheric air: from these two sources they derive their principal nourishment: from these, their extract, mucilage, oil, carbon, acids, colouring parts, &c. are produced. Since the discovery of the different gases, it has been observed, that they grow very rapidly in air altered and mixed with carbonic acid, as well as in hydrogen gas. We have already taken notice,

that leaves decompose water and carbonic acid. From the former, they absorb hydrogen; and from the second, carbon; disengaging from both vital air. They appear likewise to absorb azot. These well known phenomena explain the formation of carbon and of oil: for there can be no doubt that the latter of these principles consists of hydrogen fixed by carbon, if the expression may be used, as it affords much water and carbonic acid during its combustion. But we are still ignorant of the manner in which the colouring principle, the different oils, the aroma, the fixed alkali, and the glutinous part, &c. are formed; we can only venture to foretel, that new experiments on vegetation, in prosecution of these new views, will hereafter explain the nature and the composition of all these different immediate principles.

We are now beginning to understand the formation of vegetable acids, during vegetation, and even by that act. In the history of acids, we have already taken notice, that they appear to be all formed of similar bases: that, by an ultimate analysis, we obtain equally from them all, carbon, hydrogen, and oxygen; and that they seem to differ only in the proportions of the principles, and in the compression of density of the substances. The more we extend our experiments upon acids, the more probable will this opinion become.

Scheele and Crell have found an analogy to exist among several of them. Scheele, who at first thought the oxalic acid and the acid of sugar to be different from each other, has at length proved, as we have mentioned elsewhere, that there is no difference between these acids, but that they are precisely the same: 1. By extracting the portion of potash which conceals the properties of the oxalic acid in common salt of forrel, and by that means reducing it to the state of pure oxalic acid: 2. By changing *acid of sugar* into salt of forrel, by the addition of a little potash.

If to this important fact in the analysis of vegetables, we add the valuable experiments of Crell, who has extracted tartareous acid from alcohol, and has changed tartareous acid into vinegar, and into oxalic acid, and oxalic acid again into acetous acid; we shall see, that the oxalic, the tartareous, and the acetous acids greatly resemble each other; that they are formed

from one base, and differ only in the proportions of the oxygen which they contain. It appears that the tartareous acid contains least of this principle; that the oxalic acid contains much more of it; and that the acetous acid contains still more than either of the other two. I cannot help thinking, that if four vegetable acids, which were at first thought to be essentially different from each other, have been already found to consist of the same base, combined with different proportions of oxygen; future experiments may in like manner discover the same analogy to subsist among others, particularly between the citric and malic acids, which are so often found together in vegetable juices. These assertions are supported by some experiments on the analysis of the quinquina of St. Domingo, which are inserted in one of the volumes of the *Annals of Chemistry*.

Lastly, Our present knowledge of the theory of vegetation, already explains to us the influence of manures. Parmentier is the first and almost the only natural philosopher that has begun to apply this theory to agriculture, in a memoir which he read to the Agricultural Society of Paris, in June 1791.

XII. Vinous fermentation, the simultaneous formation of the carbonic acid and alcohol, the necessity of water and a saccharine principle to begin that fermentation, all together afford us reason to think, that it is produced by the decomposition of water. The oxygen of the water combining with the carbon, forms carbonic acid, which is disengaged; and the alcohol is formed by the fixation of the hydrogen in the oily base, which, with different quantities of oxygen, forms the tartareous, the oxalic, and the acetous acids. This theory explains fully the reason why alcohol is so light, why it affords so much water in combustion, why it is changed by mineral acids into oxalic acid, acetous acid, &c. It is true, we do not yet well understand how it passes into the state of ether; only it is probable, that in such operations, the alcohol loses a portion of its hydrogen, which goes to the formation of water.

XIII. Chemists are beginning to conjecture, how far the science can conduct them in their inquiries into the formation of animal matters. Digestion seems to be simply an extraction or solution by the gastric juice. The fixation of azotic gas is

one of the principal functions of organization. From the experiments of Scheele, and still more from those of Berthollet, it appears to form the principal difference between animal matters and vegetable substances. It contributes to the formation of the ammoniac which these substances afford in such abundance by distillation, &c. Respiration appears to be one of the most powerful means employed by nature for increasing the quantity of azot in animal substances.

The differences among the animal fluids designed for the nourishment of the different organs, and the peculiar nature of the gelatinous humour, of the albuminous liquor, and of the fibrous part, which is melted and dissolved in certain fluids, are now sufficiently ascertained. We know that the former is the least animalized, that the second is more so, and that the third is the last substance produced by the action of the vital functions upon the fluids: we know also, that this last *humour* is reunited simply by rest into a tissue of solid fibres; and that the albuminous part is thickened, and rendered concrete by heat; whereas the gelatinous substance is sooner disposed to melt, but also more readily reproduced. Peculiar acids have been found in the excrementitious humours; but we know nothing of their formation: we are particularly ignorant of the manner in which the phosphoric acid, which abounds so generally throughout this kingdom, is formed.

The nature of the solids of animals has engaged the attention of modern chemists. The distinctive nature of the fibrous texture of the muscles, of the membranous plates, of the hard laminae of the bones, &c. is now known. Medicine expects from the discoveries of chemistry, a solution of the problems which still subsist concerning the formation of the several matters which constitute these parts; especially the phosphoric acid, the albuminous juice, the fibrous matter, calcareous phosphat, and the peculiar oils which are found in this kingdom of nature. The formation of ammoniac, which was guessed at by Bergman and Scheele, and has been since fully explained by Berthollet, affords us reason for thinking, that all these problems may be successively solved. In all probability, we want only a few principal facts, to enable us to reach several

important results : the hope of this must encourage those physicians who know the importance of chemistry.

XIV. Ever since the days of Chancellor Bacon, the history of putrefaction has been acknowledged as an important object in medical inquiries. Several eminent naturalists have studied it with some success : But the cause of this decomposition, and the manner in which it is effected, have not been yet discovered. The late discoveries throw some light on this important point. Water, which promotes and excites putrefaction, is understood to be decomposed in that intestine motion. We understand how ammoniac is formed in such abundance, by the fixation of azotic gas and hydrogen gas. The slow decomposition of fat, its preservation and condensation, of which the last in some instances proceeds to solidity and hardness, in consequence of the fixation of vital air from water, are now accounted for : in like manner have been explained, the volatilization and reduction of dead animal substances exposed to the air into elastic fluids ; in a word, the complete separation of all those principles, and their dispersion in the atmosphere, which conveys them into new combinations ; with that whole series of compositions, and transitions of substances out of one kingdom into another, so happily expressed by Beccher, under the philosophical emblem, *circulus aeterni motus*, which he uses to signify the always active powers of nature.

AN
EXPLANATION

OF THE

TABLE OF NOMENCLATURE*.

WE shall first observe, that our intention in drawing up this Table has not been to offer the whole Nomenclature of Chemistry, but to unite, under several classes of compounds, a sufficient number of select examples, in order that, by means of a simple and easy study, our method of naming might be applied to all the compounds which are known to chemists, or to those which they may hereafter discover. To answer this purpose, we have divided our table into six perpendicular columns, at the head of which are placed the general titles, which announce the state of the bodies whose names are found therein.

Each of these columns is divided into 55 separate compartments, one beneath the other. This number is determined by that of the substances not yet decomposed which we are acquainted with, and which are inserted in the first column. The correspondent horizontal divisions of the five following columns, comprehend the principal combinations of these simple substances, and must therefore be equally numerous in each column.

* See Table II. at the end of this Volume.

We shall proceed to give an account of the principal circumstances which offer themselves in the consideration of these columns.

COLUMN THE FIRST.

The first column, marked by the Roman numeral I. is entitled, *Substances not decomposed*. We must here remark, that these bodies are simple to us only because we have not yet succeeded in analysing them. All the accurate experiments which have been made for the last ten years, show that these bodies cannot be separated into substances of a more simple nature, and that they cannot be reproduced by artificial compositions. These substances are, as we have already observed, 55 in number. Opposite each of these is placed, in Arabian characters, the number which denotes the place of each body, and of its correspondent compounds in the other columns.

The horizontal lines are, therefore, by this disposition, continued absolutely from the first column to the sixth; and all the horizontal compartments of each column are comprehended and denoted by the same number.

The 55 simple substances in the first column are divided into five classes, according to the comparative nature of each. The first division comprehends four bodies, which seem to approach nearest to the idea which has been formed of elements, and which perform the most active part in combinations: these are, light (1 compartment); heat (2), hitherto called the matter of heat; oxygen (3), or that part of vital air which is fixed in bodies which burn, which augments their weight, changes their nature, and whose character or most eminent property being that it forms acids, has induced us to derive its name from this remarkable property: hydrogen (4), or the base of the elastic fluid called inflammable gas, a substance which exists in the solid form in ice, because it is one of the principles of water. These four first simple substances are connected by a bracket.

The second class of substances not yet decomposed in the first column comprehends twenty-six different bodies, all of

which possess the property of becoming acid by their unions with the oxygen, and which, from this common character, we denote by the words acidifiable bases. Among these twenty-six bodies, there are only four which have yet been obtained simple and uncombined; these are azot, or the nitric radical* (compartment 5), or the solid base of atmospheric mephitic, well known at present to chemists; pure charcoal, carbon, or the carbonic radical (6); sulphur, or the sulphuric radical (7); and phosphorus, or the phosphoric radical (8). The twenty-two others are only known in their combinations with oxygen, and in the state of acids; but in order to give a greater degree of perspicuity and extent to the science, we have separated them from oxygen in idea, and we suppose them in that state of purity to which it is very probable that art will hereafter succeed in reducing them. They are all denominated by the names of their acids, with an uniform termination, which are followed by the generic word radical. Such is the manner in which the expressions, muriatic radical (compartment 9), boracic radical (10), fluoric radical (11), succinic radical (12), acetic radical (13), tartaric radical (14), pyrotartaric radical (15), oxalic radical (16), gallic radical (17), citric radical (18), malic radical (19), benzoic radical (20), pyrolignic radical (21), pyromucic radical (22), camphoric radical (23), lactic radical (24), saccholactic radical (25), formic radical (26), prussic radical (27), sebacic radical (28), lithic radical (29), bombic radical (30), are to be understood.

The third class of the undecomposed bodies of column I. contains the metallic substances, which are seventeen in number, from the compartment 31 to 47, inclusive. All these possess the names by which they are known at present. The three first are capable of passing to the acid state, and are by this character related to the acidifiable bases which precede them.

In the fourth class of substances not decomposed, are placed the earths, silex (compartment 48), alumine (49), barytes (50), lime (51), magnesia (52). These five earths have not

* It must here be observed, likewise, that azot has not been obtained alone and insulated, but combined with caloric, and in the state of gas.

yet been decomposed, and they must be considered as simple substances, in the present state of our knowledge.

Lastly, The fifth class of substances not decomposed includes the three alkalis, potash (compartment 53), soda (54), ammoniac (55). Although this last has been already decomposed by Bergman and Scheele, and though Berthollet has precisely determined the nature and quantity of its principles, we have thought proper to arrange it beneath the fixed alkalis, of whose component parts there are hopes we shall speedily attain a knowledge; and in order to avoid interrupting the connection of these substances, which in many respects act as substances not decomposable in the experiments of chemistry.

The first column, whose divisions have been here spoken of, is longitudinally divided into two parts, like all the others; the part on the right hand is appropriated to the ancient names, distinguished by the Italic character.

COLUMN THE SECOND.

The second column is entitled, *Converted into the state of Gas by Caloric*. It is necessary to connect with this title that of the preceding column, and to read, *Substances not yet decomposed, converted into the State of Gas by Caloric*. It will hence be easily understood, that this second column is designed to exhibit the permanent aeriform state which several of the simple substances, enumerated in the first column, are capable of assuming. We find in the present column, no more than four elastic fluids, whose names, as well as all the words contained in the other columns, are derived from those of the undecomposed substances, and become simple and clear by the addition of the word gas, which precedes the former names. Thus we find, in the third compartment, oxygenous gas or vital air; in the fourth, hydrogenous gas; in the fifth, azotic gas; and in the fifty-fifth, ammoniacal gas. The ancient names are inserted in the adjoining opposite column.

COLUMN THE THIRD.

At the head of this column we read the words, *Combined with Oxygen*. It must constantly be supposed that the title of the first column is prefixed, and it is then perceived that the *substances not hitherto decomposed* are the things spoken of. This column is one of the fullest, because almost every substance in the first column is capable of combining with oxygen. When we cast our eyes over its disposition, and the names which it exhibits, we see immediately that these names are all composed of two words which express compounds of two substances; the latter of these words is the generic term of acid which indicates the saline character given by the oxygen; the former specifies each acid, and is almost always that of the radical indicated in the first column. The fifth compartment of this third column presents the union of azot, or the nitric radical, with oxygen, and there result three known compounds from this union of two bodies, according to the proportions of their principles. In fact, the azot, either contains the least possible quantity of oxygen, and then forms the base of nitrous gas; or is saturated with it, and then constitutes the nitric acid; or it contains less oxygen than this last, but more than nitrous gas, and forms nitrous acid. We see that it is simply by changing the termination of the same word, that we have expressed the three states of this combination. It is absolutely the same with regard to the sulphuric acid (compartment 7), the phosphoric acid (8), the acetic acid (13). Each of these acids may exist in two states of combination with oxygen, according to the quantities which their radicals, or acidifiable bases, may contain. When their bases are completely saturated, the results are the sulphuric, acetic and phosphoric acids. When these bases are not saturated, and are, as it were, in excess with regard to the quantity of oxygen, we name them the sulphureous, acetous, and phosphoreous acids, as appears in the compartments already referred to. This termination serves thus to denote the state of the acids according to the names already employed, of vitriolic and sulphureous; and we adopt it as a rule equally general and simple for all the other acids

which are in either of these states: it will be easy to understand, after this, the names of the carbonic acid (compartment 6), the boracic acid (10), and of all those which exhibit only a single state, in which the acidifiable base is saturated with oxygen. By the same law of this nomenclature we understand that the acids which are placed alone in a compartment, and whose names terminate in *ous*, contain an excess of acidifiable matter; such are the tartareous acid (compartment 14), the pyrotartarous acid (15), the pyroligneous acid (21), and the pyromucous acid (22). The muriatic acid (compartment 9), is found in a different state from all the others; besides its acid combination saturated with oxygen, it is capable of acquiring an excess of this principle, and then obtains singular properties: to distinguish it in this peculiar state, we call it the oxygenated muriatic acid (column 9); and this first simple name, whose value is well determined, may be hereafter applied to other acids, if they should be discovered to possess the property of becoming surcharged with oxygen.

The lower compartments of this third column, from 31 to 47 inclusively, exhibit the nomenclature of another system of bodies. We find the word oxyd prefixed to the compound denomination; the reasons have been elsewhere explained, which have engaged us to substitute this name instead of metallic calces. It is easy to see that, without expressing the saline quality as the word acid does, this term, nevertheless, equally well denotes a combination of oxygen; besides which, it affords the advantage that it can be employed to denote all bodies capable of uniting with oxygen, and which, in this union, do not form acids, whether because the quantity of oxygen is not sufficiently abundant, or because their bases are not of an acidifiable nature. Thus, for example, the phosphoric acid, vitrified or deprived of a portion of oxygen by the action of a strong heat, is a kind of phosphoric oxyd. Nitrous gas, which is no more acid than phosphoric glass, because it does not contain a sufficient quantity of oxygen, is likewise a true nitrous oxyd. So likewise hydrogen, united to oxygen, does not form an acid; but this union constitutes water, which, considered under the present point of view, may be regarded as an oxyd of hydrogen.

Among the seventeen metallic oxyds, which are exhibited from compartment 31 to 48, there are three which are intermediate between the metallic and acid states. It is for want of oxygen, that the oxyds of arsenic (compartment 31), molybdena (32), and tungsten (33), are not yet acids. A greater quantity of this generative principle of acidity forms the arsenic, molybdic and tungstic acids in the same columns. It has been explained how epithets, taken from the colour or the processes, serve us to distinguish the several oxyds of the same metal, as may be seen at the articles oxyds of antimony (compartment 38), oxyds of lead (42), and oxyds of mercury (44), which afford the most numerous examples of this diversity.

COLUMN THE FOURTH.

The fourth column, whose title is, *Oxygenated Gaseous*, announces the simple substances, combined at the same time with oxygen and a sufficient quantity of caloric to convert them into the state of permanent gas, at the usual pressure and temperature. This exhibits only six substances known to exist in this state; namely, nitrous gas, and nitrous acid gas (compartment 5), carbonic acid gas (6), sulphureous gas (7), muriatic acid and oxygenated muriatic acid gases (9), and the fluoric acid gas (11). As no other of these oxygenated substances have been hitherto placed in the state of gas by caloric, most of the compartments of this last column are empty: we have availed ourselves of this circumstance to insert peculiar combinations of metallic oxyds, or oxygenated metals with various substances; this column is therefore divided in the middle, and takes the new title of *Metallic Oxyds, with various Bases*. The compartments 31, 32, 36, 37, 38, 39, 40, 41, 42, 43, 44, and 45, exhibit combinations of metallic oxyds, with sulphur, and with the alkalis; the former bear the epithet of sulphurated oxyds of arsenic and lead, and the latter that of alkaline metallic oxyds: when any of these compounds vary in the proportions of the component parts, and consequently in their properties, we distinguish them like the simple

oxyds. by second epithets taken from their colour; thus we say, the gray, red, orange coloured, &c. fulphurated oxyds of antimony, compartment 38.

COLUMN THE FIFTH.

As the fifth column, which comprehends simple oxygenated substances with bases, or the neutral salts in general, offers a greater number of names than the foregoing. it appeared necessary to us to exhibit a greater number of examples to show the advantage which this methodical Nomenclature possesses over the ancient names, most of which, though used to express similar compositions, were themselves entirely dissimilar.

A slight inspection of the compartments of this column will show that uniformity of termination prevails in all the names it contains, the constant use of which in our Nomenclature is to express analogous compounds. It is easy to conceive that this regular process will singularly facilitate the study of the science, and produce the greatest perspicuity in chemical works. The substances inserted in this 5th column are all compounds of three substances; acidifiable bases, the acidifying principle, or oxygen, and earthy, alkaline, or metallic bases: nevertheless, their nature is pointed out by two words only; because the first, which is derived from that of the oxygenated, or acid combination, includes itself in the expression of this union, and the second belongs solely to the base which saturates the acid. All the names of these compounds are terminated in *ate*, when they contain the acids in their state of complete saturation, by oxygen; their termination is in *ite*, when the acids are deprived of a certain quantity of oxygen. Upon inspecting the compartments of this column, from the 5th to the 34th, it will be seen, that we have inserted a greater number of examples *, in proportion as the acids to which they correspond,

* The neutral salts are at present very numerous; twenty-nine known acids, each of which may be saturated by four soluble earths, three alkalis, and fourteen metallic oxyds, which are not acidifiable (for it appears that the acidifiable oxyds, such as those of arsenic, molybdena, and tungsten, cannot neutralize the mineral acids), form 609 species of compound salts. If we add that five of these

or whose saline compounds they contain, are more known and used: these compartments exhibit some of the principal differences in the Nomenclature.

1. The greater number comprehend salts whose names are terminated in *at*, as the carbonats (compartment 6), the fluats (11), the fuccinats (12), the gallats (17), the citrats (18), the malats (19), the benzoats (20), the camphorats (23), the lactats (24), the saccholats (25), the formiats (26), the prussiates (27), the sebats (28), the lithiats (29), the bombiats (30), the arseniats (31), the molybdats (32), the tungstats (33). This identical and uniform termination of these eighteen genera of neutral salts, shows that the acids which constitute them are not known but in their state of complete saturation by the oxygen; these acids, therefore, in the third column are all terminated in *ic*, according to the rules of our Nomenclature.

2. In considering the compartments 14, 15, 21, and 22, of the 5th column, we find only the tartrits, pyrotartrits, pyrolignits, pyromucits, whose uniform termination denotes acids with excess of their acidifiable bases, and that they contain the tartareous, pyrotartareous, pyroligneous, and pyromucous acids.

3. There is, in the same column, a third class of compartments, in which we find, at the same time, neutral salts whose names have the two terminations here spoken of; such are the compartments 5, in which we find nitrats and nitrits; 7, which contains sulphats and sulphits; 8, which exhibits the phosphats and phosphits; and 13, which includes the acetats and

acids, viz. the nitric, the sulphuric, the muriatic, the acetic, and the phosphoric are likewise capable of entering into combinations, in their two different states with neutralizable bases, and that several acids, such as the sulphuric, tartareous, oxalic and arsenic acids, are capable of saturating various quantities of the bases, and forming what we call acidules, of which eight very distinct species are already known (such are the acidulous sulphat of potash, or vitriolated tartar with excess of acid; the acidulous tartarits, or oxalats of potash, of soda, of ammoniac, or the creams of tartar, and salts of sorrel, made artificially, with the pure tartareous and oxalic acids, united to a small quantity of alkaline bases, and the acidulous arseniat of potash, or the neutral arsenical salt of Macquer), we shall see that the number of neutral salts may be carried to as far as 722 species, whose denominations may be formed methodically, after the 46 or 48 examples of these salts, exhibited in the present table.

acids: this double termination in each of the compartments sufficiently points out, from what we have before explained, that the salts to which we have applied them are formed by the same acid in two proportions of union with oxygen, always calling to mind that the acids terminating in *ic* form neutral salts terminated in *at*, and that those whose termination is in *ous*, constitute neutral salts terminated in *it*.

4. In several compartments of this column we have given examples of different neutral salts from those of the two classes hitherto distinguished. Thus, in compartment 9, we have distinguished by the name of oxygenated muriat of potash, the combination of the oxygenated muriatic acid with potash, a salt which is very different from the muriat of potash, and in which Berthollet has distinguished the property of detonating on burning coals. We have likewise, in other compartments of the same column, expressed the saline combinations in which the acids predominate, by adding to the methodical denominations of these salts, the epithet acidulous. Thus, in the compartment 14, we read, acidulous tartrit of potash, and in 16, the acidulous oxalat of potash. Lastly, We have distinguished by the expression supersaturated, such salts in which the base predominates, as may be seen in the compartment 8, where we find supersaturated phosphat of soda; and 10, where we find borax, or supersaturated borat of soda.

When it is considered how rigorous and etymological the method is which we have followed to denominate neutral salts, and the very small degree of coincidence among them in the names given to the like salts in the ancient nomenclature, it will be seen why this column exhibits the greatest number of variations and changes, though we have really made no other innovation than by adding two varied terminations to the names already known.

COLUMN THE SIXTH.

The sixth and last column of this table, which comprehends simple substances combined in their natural state, and without being oxygenated or acidified, as the title shows, is one of the

shortest, and contains only a small number of compounds. The lower compartments, from 31 to 48, contain compounds of metals with each other, to which we preserve the names of alloys and amalgams, which have hitherto been adopted. Above these we find only three which exhibit a new nomenclature, founded on the same principles as the preceding. Compartment 6 exhibits the expression *carbure of iron*, which denotes the combination of charcoal in substance with iron, called plumbago. Compartment 7 exhibits the metallic sulphures, or the combinations of sulphur in substance with the metals; the alkaline sulphures, or combinations of sulphur with the alkalis; the sulphurated hydrogenous gas, or solution of sulphur in hydrogenous gas: and lastly, in compartment 8, we express by the generical name of metallic phosphures, the compounds of phosphorus in substance with the metals. Thus, instead of the word siderite, we substitute the expression phosphure of iron, which unequivocally denotes the union of phosphorus with iron. And we find, in these three comparable words, carbure, sulphure, and phosphure, which differ only in their termination from names which are very well known, a means of conveying an accurate idea of analogous compounds, and of distinguishing them from all other compounds.

Underneath these six columns we have placed numerically, the principal compound substances which constitute vegetables. In this part of the table we have chosen out of the ancient names those which, by their simplicity and clearness, enter completely into the views we have proposed.

Such is the method which we have followed in the assemblage of names comprehended in this table. After the easy study which the table requires on the part of such as are desirous of becoming acquainted with our plan, it will soon be perceived that we have invented only a very small number of words, if we except those which were indispensably necessary to denote substances before unknown, such as are the newly discovered acids. By following the order of the substances named in the first column, from which all the other names are derived, it will be seen that we have no other new words than oxygen, hydrogen, and azot. With regard to the words ca-

loric, carbon, filix, and ammoniac, they, as well as their derivatives in the following columns, exhibit only slight changes from names already very well known, and much used. We can therefore affirm, that our nomenclature differs from the ancient almost entirely in its terminations only; and that if from these changes there should result a greater facility in study, and greater perspicuity in expression; if, more especially, they should afford the means of avoiding every equivocal expression, as the trial which has already been made, in the years 1787 and 1788, in the lectures at the Royal Garden and the Lyceum, gives us reason to hope, the reformation which we propose, founded upon a simple method, cannot but be favourable to the progress of chemistry.

ANCIENT AND NEW SYNONYMA

IN ALPHABETICAL ORDER.

Ancient Names.

New Names.

ACETOUS ammoniac

Acetous salt of clay

Acetous salt of copper

Acetous salt of iron

Acetous salt of lead

Acetous salt of lime

Acetous salt of magnesia

Acetous salt of mercury

Acetous salt of soda

Acetous salt of tartar

Acetous salt of zinc

Acid acetous

Acid aerial

Acid of alum

Acid of amber

Acid of ants

Acid of apples

Acid arsenical

Acid of benzoin

Acid boracic

Acid of borax

Acid of chalk

Acid of charcoal

Acid cretaceous

Acid of fat

Acid of galls

Acid of galls alcoholized

Acid of lemons

Acetit ammoniacal.
— of ammoniac.

Acetit aluminous.
— of alumin.

Acetit of copper.

Acetit of iron.

Acetit of lead.

Acetit of lime.

Acetit of magnesia.

Acetit of mercury.

Acetit of soda.

Acetit of potash.

Acetit of zink.

Acetous acid.

Carbonic acid.

Sulphuric acid.

Succinic acid.

Formic acid.

Malic acid.

Arsenic acid.

Benzoic acid.

Boracic acid.

Boracic acid.

Carbonic acid.

Carbonic acid.

Carbonic acid.

Sebacic acid.

Gallic acid,

Gallic alcohol.

Citric acid.

*Ancient Names.**New Names.*

Acid lignic, or of box	-	Pyroligneous acid.
Acid malufian	-	Malic acid.
Acid marine	-	Muriatic acid.
Acid marine dephlogifticated	-	Oxygenated muriatic acid.
Acid mephitic	-	Carbonic acid.
Acid of molybdena	-	Molybdic acid.
Acid of muria	-	Muriatic acid.
Acid of nitre	-	Nitric acid.
Acid of nitre pale or colourless	-	Nitric acid.
Acid of nitre deprived of its gas	-	Nitric acid.
Acid of nitre dephlogifticated	-	Nitric acid.
Acid of nitre phlogifticated	-	Nitrous acid.
Acid perlate	-	Supersaturated phosphat of soda.
Acid of phosphorus dephlogifticated	}	Phosphoric acid.
Acid of phosphorus phlogifticated	}	Phosphoreous acid.
Acid of sea-salt	-	Muriatic acid.
Acid of silk-worms	-	Bombic acid.
Acid of spar or fluor	-	Fluoric acid.
Acid of sugar	-	Oxalic acid.
Acid of sulphur	-	Sulphuric acid.
Acid of tungstein or tungsten	-	Tungstic acid.
Acid of wolfram of Messrs. Delhuyar	}	Tungstic acid.
Acid saccharine	-	Oxalic acid.
Acid saccholactic, or acid of the sugar of milk	}	Saccholactic acid.
Acid sebaceous, or of fat	-	Sebacic acid.
Acid sedative	-	Boracic acid.
Acid sulphureous	-	Sulphureous acid.
Acid syrupous	-	Pyromucous acid.
Acid tartareous	-	Tartareous acid.
Acid vitriolic	-	Sulphuric acid.
Acid phlogifticated vitriolic	-	Sulphureous acid.
Acidum pingue	-	{ The hypothetical principle of Meyer.
Affinities	-	Chemical affinities or attractions.
Aggregation	-	Aggregation.
Air alkaline	-	Ammoniacal gas.
Air atmospherical, or common air	}	Atmospherical or common air.
Air, dephlogifticated of Dr. Priestley	}	Oxygenous gas or vital air.
Air, dephlogifticated marine acid	}	Oxygenated muriatic acid gas.
Air factitious	-	Carbonic acid gas.
Air, fœtid, of sulphur	-	Sulphurated hydrogenous gas.
Air, fire, of Scheele	-	Oxygenous gas.

*Ancient Names.**New Names.*

Air, fire, of Dr. Black	Carbonic acid gas.
Air impure	Azotic gas.
Air inflammable	Hydrogenous gas.
Air, marine acid	Muriatic acid gas.
Air nitrous	Nitrous gas.
Air phlogisticated	Azotic gas.
Air pure	Oxygenous gas, or vital air.
Air, solid, of Hales	Carbonic acid gas.
Air vitiated	Azotic gas.
Air vital	Oxygenous gas.
Air, vitriolic acid, of Dr. Priestley	Sulphureous acid gas.
Alkahest	{ The universal solvent of the al-
	{ chemists.
Alkahest of Respour	{ Potash mixed with oxyd of
	{ zink.
Alkahest of Van Helmont	Carbonat of potash.
Alkalis in general	Alkalis.
Alkalis aerated	Alkaline carbonats.
Alkalis caustic	Alkalis.
Alkalis effervescent	Alkaline carbonats.
Alkali fixed, of tartar, caustic	Potash.
Alkali, fixed, of tartar, not caustic	Carbonat of potash.
Alkali, fixed vegetable	Carbonat of potash.
Alkali marine, caustic	Soda.
Alkali marine, not caustic	Carbonat of soda.
Alkali mineral acetated	Acetit of soda.
Alkali mineral aerated	Carbonat of soda.
Alkali phlogisticated	{ Ferruginous prussiat of potash,
	{ not saturated.
Alkali Prussian	Ferruginous prussiat of potash.
Alkali urinous	{ Carbonat of ammoniac.
	{ Ammoniacal carbonat.
Alkali vegetable aerated	Carbonat of potash.
Alkali volatile acetated	{ Ammoniacal acetit.
	{ Acetit of ammoniac.
Alkali volatile mild	{ Ammoniacal carbonat.
	{ Carbonat of ammoniac.
Alkali volatile fluor	Ammoniac.
Alkali volatile caustic	Ammoniac.
Alkali volatile concrete	Ammoniacal carbonat.
Alkali volatile mephitized	Carbonat of ammoniac.
Alloy or alloy of metals	Alloy.
Alum	{ Sulphat of alumine.
	{ Aluminous sulphat.
Alum marine	{ Muriat of alumine.
	{ Aluminous muriat.
Alum nitrous	{ Nitrit of alumine.
	{ Aluminous nitrit.
Amalgam of bismuth	Amalgam of bismuth.

*Ancient Names.**New Names.*

Amalgam of copper	-	Amalgam of copper.
Amalgam of gold	-	Amalgam of gold.
Amalgam of lead	-	Amalgam of lead.
Amalgam of silver	-	Amalgam of silver.
Amalgam of tin	-	Amalgam of tin.
Amalgam of zinc	-	Amalgam of zink.
Amber yellow	-	Amber or succinum.
Antimony crude	-	Sulphure of antimony.
Antimony diaphoretic	-	{ White oxyd of antimony by nitre.
Aqua fortis	-	Nitric acid of commerce.
Aqua regia	-	Nitro-muriatic acid.
Aqua stygia	-	{ Nitro-muriatic acid, by the am- moniacal muriat.
Aquila alba	-	{ Mild sublimated mercurial mu- riat.
Arbor Dianæ	-	CrySTALLIZED amalgam of silver.
Arcanum corallinum	-	{ Red oxyd of mercury, by the nitric.
Arcanum duplicatum	-	Sulphat of potash.
Argil pure, or argillaceous earth	-	Alumine.
Argil cretaceous	-	Aluminous carbonat.
Argil sparry	-	{ Aluminous fluat. Fluat of alumine.
Arsenic, regulus of	-	Arsenic.
Arsenic, white calx of	-	Oxyd of arsenic.
Arsenic red	-	{ Red sulphurated oxyd of arse- nic.
Arseniat of potash	-	Arseniat of potash.
Attractions elective	-	Elective attractions.
Azure of cabalt, or of the four fibres	-	{ Vitreous oxyd of cobalt and si- lex.

B.

Balfams of Bucquet	-	Balfams.
Balfam of sulphur	-	Sulphure of volatile oil.
Barilla	-	Carbonat of soda.
Barytes	-	Barytes.
Barytes effervescent	-	Carbonat of barytes.
Base of vital air	-	Oxygen.
Base of marine salt	-	Soda.
Benzoin or benjamin	-	Benzoin.
Benzoic salts	-	Benzoats.
Bezoar mineral	-	Oxyd of antimony.
Bismuth	-	Bismuth.
Bismuth muriated	-	Muriat of bismuth.
Bitumen	-	Bitumen.
Black lead	-	Carbure of iron.

*Ancient Names.**New Names.*

Blue, Berlin	Prussiat of iron.
Blue, Prussian	Prussiat of iron.
Borax	{ Borax of soda, or borat super-
	{ saturated with soda.
Borax ammoniacal	Ammoniacal borat.
Borax of zinc	Borat of zink.
Borax argillaceous	Aluminous borat.
Borax barytic or ponderous	Borat of barytes.
Borax calcareous	{ Borat of lime.
	{ Calcareous borat.
Borax magnesian	{ Magnesian borat.
	{ Borat of magnesia.
Borax martial	Borat of iron.
Borax mercurial	Borat of mercury.
Borax vegetable	Borat of potash.
Borax of antimony	Borat of antimony.
Butter of antimony	Sublimated muriat of antimony.
Butter of arsenic	Sublimated muriat of arsenic.
Butter of bismuth	Sublimated muriat of bismuth.
Butter of cobalt	Sublimated muriat of cobalt.
Butter of copper	Sublimated muriat of copper.
Butter of tin	Sublimated muriat of tin.
Butter of tin, solid, of Baumé	Concrete muriat of tin.
Butter of zinc	Sublimated muriat of zink.
Brass	Brass; alloy of copper and zink.

C.

Calces metallic	Metallic oxyds.
Calx of antimony vitrified	Vitreous oxyd of antimony.
Cameleon mineral	Oxyd of manganese and potash.
Camphor	Camphor.
Camphoric salts	Camphorats.
Causticum	Meyer's hypothetical principle.
Causticum lunare	Fused nitrat of silver.
Ceruse	{ White oxyd of lead by the ace-
	{ tous acid, mixed with carbo-
	{ nat of lime.
Ceruse of antimony	{ White oxyd of antimony by
	{ precipitation.
Chalk	{ Chalk, carbonat of lime.
	{ Calcareous carbonat.
Charcoal pure	Carbon.
Cinnabar	{ Sulphurated red oxyd of mer-
	{ cury.
Clay	{ Clay; a mixture of alumine and
	{ silice.
Cobalt	Cobalt
Colcothar	{ Red oxyd of iron by the sul-
	{ phuric acid.

*Ancient Names.**New Names.*

Copper	-	Copper.
Copper acetated	-	Acetat of copper.
Copperas green	-	Sulphat of iron.
Copperas blue	-	Sulphat of copper.
Copperas white	-	Sulphat of zink.
Cream of tartar	-	Acidulous tartrit of potash.

D.

Diamond	Diamond.
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E.

Earth, acetated calcareous	Calcareous acetit.
Earth, aerated ponderous	Carbonat of barytes.
Earth animal	Calcareous phosphat.
Earthy base of ponderous spar	Barytes.
Earth calcareous	Lime, or calcareous earth.
Earth of alum	Alumine.
Earth animal	Phosphat of lime.
Earth calcareous	Lime, or calcareous earth.
Earth magnesian	Carbonat of magnesia.
Earth muriatic, of Kirwin	Magnesia.
Earth ponderous	Barytes.
Earth filicious	Siliceous earth, or flix.
Emetic tartar	Antimoniated tartrit of potash.
Empyrean air	Oxygenous gas.
Essences	Volatile oils.
Ether acetous	Acetic ether.
Ether marine	Muriatic ether.
Ether nitrous	Nitric ether.
Ether vitriolic	Sulphuric ether.
Ethiops martial	Black oxyd of iron.
Ethiops mineral	{ Black fulphurated oxyd of mer-
Ethiops per se	cury.
Extract	Blackish mercurial oxyd.
	Extract.

F.

Fecula of vegetables	Fecula.
Flowers, ammoniacal cupreous	{ Sublimated ammoniacal muriat,
Flowers argentine, of regulus of } antimony	{ of copper.
Flowers metallic	Sublimated oxyd of antimony.
Flowers of arsenic	Sublimated metallic oxyds.
	Sublimated oxyd of arsenic.

*Ancient Names.**New Names.*

Flowers of benzoïn	-	Sublimated benzoic acid.
Flowers of bismuth	-	Sublimated oxyd of bismuth.
Flowers of sulphur	-	Sublimated sulphur.
Flowers of tin	-	Sublimated oxyd of tin.
Flowers of zinc	-	Sublimated oxyd of zink.
Fluids aeriform	-	Gas.
Fluids elastic	-	Gases.
Fluor ammoniacal	-	{ Fluat of ammoniac.
		{ Ammoniacal fluat.
Fluor argillaceous	-	{ Aluminous fluat.
		{ Fluat of alumine.
Fluor of magnesia	-	Fluat of magnesia.
Fluor of potash	-	Fluat of potash.
Fluor of soda	-	Fluat of soda.
Fluor ponderous	-	Barytic fluat.

G.

Gas	-	Gas.
Gas, acetous acid	-	Acetous acid gas.
Gas, aerial muriatic acid	-	Oxygenated muriatic acid gas.
Gas alkaline	-	Ammoniacal gas.
Gas, cretaceous acid	-	Carbonic acid gas.
Gas hepatic	-	Sulphurated hydrogenous gas.
Gas inflammable	-	Hydrogenous gas.
Gas, inflammable carbonated	-	Carbonated hydrogenous gas.
Gas, inflammable of marshes	-	{ Marsh hydrogenous gas (mix-
		{ ture of carbonated hydroge-
		{ nous gas and azotic gas.)
Gas mephitic	-	Carbonic acid gas.
Gas, marine acid	-	Muriatic acid gas.
Gas nitrous	-	Nitrous gas.
Gas phlogificated	-	Azotic gas.
Gas phosphoric, of Mr. Gen-	}	Phosphorated hydrogenous gas.
gembre		
Gas of Prussian blue	-	Prussic acid gas.
Gas, sparry acid	-	Fluoric acid gas.
Gas, sulphureous	-	Sulphureous acid gas.
Gas sylvestre, of Helmont	-	Carbonic acid gas.
Gilla vitrioli	-	Sulphat of zink.
Glutinous matter of wheat	-	Gluten.
Gold	-	Gold.
Gold muriated	-	Muriat of gold.
Gold fulminating	-	Ammoniacal oxyd of gold.

*Ancient Names.**New Names.*

H

Hepars
Heat latent

Sulphures.
Caloric.

I.

Ink sympathetic by cobalt
Iron, or mars
Iron aerated
Iron acetated
Jupiter

Muriat of cobalt.
Iron.
Carbonat of iron.
Acetit of iron.
Tin.

K.

Kermes mineral

{ Red sulphurated oxyd of anti-
mony.

L.

Lapis infernalis
Lead, or saturn
Lead muriated
Lead sparry
Lead subacetated
Lead superacetated
Lemon-juice
Ley of soap
Lignic salts
Lilium Paracelsi
Lime-water
Lime-water, Prussian
Liquor, Boyle's fuming
Liquor, Silicum
Liquor, Libavius's fuming
Liquor saturated with the colour-
ing matter of Prussian blue

Fused nitrat of silver.
Lead.
Muriat of lead.
Carbonat of lead.
{ White oxyd of lead by the ac-
etous acid.
Acetit of lead.
Citric acid.
Solution of soda.
Pyro-lignites.
Alcohol of potash.
Lime-water.
Prussiat of lime.
Ammoniacal sulphure.
Siliciated potash, in solution.
Fuming muriat of tin.]
Prussiat of potash.

Litharge

{ Semi-vitreous oxyd of lead, or
litharge.

Light

Light.

Liver of antimony

Sulphurated oxyd of antimony.

Liver of arsenic

Arsenical oxyd of potash.

Livers of sulphur

Alkaline sulphures.

Livers of sulphur, earthy

Earthy sulphures.

Liver of sulphur, antimoniated

Antimoniated alkaline sulphure.

Liver of sulphur, calcareous

{ Calcareous sulphure.
Sulphure of lime.]

*Ancient Names.**New Names.*

Liver of sulphur, barytic	{ Barytic sulphure.
	{ Sulphure of barytes.
Liver of sulphur, magnesian	{ Sulphure of magnesia.
	{ Magnesian sulphure.
Liver of sulphur, volatile alkaline	{ Ammoniacal sulphure.
	{ Sulphure of ammoniac.
Luna cornea	Muriat of silver.

M.

Magistery of bismuth	{ Oxyd of bismuth by the nitric acid.
Magistery of lead	Precipitated oxyd of lead.
Magistery of sulphur	Precipitated sulphur.
Magnesia alba	Carbonat of magnesia.
Magnesia aerated, of Bergman	Carbonat of magnesia.
Magnesia black	Black oxyd of manganese.
Magnesia caustic	Magnesia.
Magnesia cretaceous	Carbonat of magnesia.
Magnesia effervescent	Carbonat of magnesia.
Magnesia fluorated	Fluat of magnesia.
Magnesia sparry	Fluat of magnesia.
Malusit salts	Malits of potash, of soda, &c.
Manganese	Manganese.
Massicot	Yellow oxyd of lead.
Matter of heat	Caloric.
Matter of fire	{ This term has been used to signify light, caloric, and phlogiston.
Matter pearly of Kerkringius	{ White oxyd of antimony by precipitation.
Matter colouring of Prussian blue	Prussic acid.
Mephitized metals, earths, &c.	Carbonats of metals, &c.
Mephitis atmospheric	Azotic gas.
Mercury	Mercury.
Mercury acetated	Acetit of mercury.
Mercurius dulcis	Mild mercurial muriat.
Mercury, white precipitate of	{ Mercurial muriat by precipitation.
Mercury of metals	Beccher's hypothetical principle.
Minium	Red oxyd of lead, or minium.
Molybdena	Molybdena.
Molybdena, saline compounds of	Molybdats.
Mother water	Deliquescent saline residue.
Mucilage	Mucus.
Muriated metals	Muriats of different metals.
Muriated gold, or reguline salt of gold	Muriat of gold.

N.

*Ancient Names.**New Names.*

Natron, or natrum	Carbonat of soda.
Nitre	Nitrat of potash, or nitre.
Nitre ammoniacal	Ammoniacal nitrat.
Nitre argillaceous	Nitrat of alumine.
Nitre calcareous	{ Nitrat of lim.
	{ Calcareous nitrat.
Nitre cubic	Nitrat of soda.
Nitre fixed	Carbonat of potash.
Nitre lunar	Nitrat of silver.
Nitre of arsenic	Nitrat of arsenic.
Nitre of bismuth	Nitrat of bismuth.
Nitre of cobalt	Nitrat of cobalt.
Nitre of copper	Nitrat of copper.
Nitre of iron	Nitrat of iron.
Nitre of lead	Nitrat of lead.
Nitre of magnesia	Nitrat of magnesia.
Nitre of manganese	Nitrat of mang a
Nitre of nickel	Nitrat of nickel.
Nitre of ponderous earth	{ Barytic nitrat.
	{ Nitrat of barytes.
Nitre of silver	Nitrat of silver.
Nitre of tin	Nitrat of tin.
Nitre of zinc	Nitrat of zink.
Nitre prismatic	Nitrat of potash.
Nitre quadrangular	Nitrat of soda.
Nitre rhomboidal	Nitrat of soda.
Nitre saturnine	Nitrat of lead.

O.

Ochre	Yellow oxyd of iron.
Oil of lime	Calcareous muriat.
Oil of tartar per deliquium	{ Potash in deliquescence mixed
	{ with carbonat of potash.
Oil of vitriol	Sulphuric acid.
Oils ethereal	Volatile oils.
Oils animal	Volatile animal oils.
Oils empyreumatic	Empyreumatic oils.
Oils essential	Volatile oils.
Oils by expression	Fixed oils.
Oils fat	Fixed oils.
Oils unctuous	Fixed oils.
Oleum philosophorum	Fixed empyreumatic oils.
Ore of antimony	Native sulphure of antimony.
Ore of iron, of marshes	{ Iron ore, containing phosphat
	{ of iron.

*Ancient Names.**New Names.*

P.

Pewter	Alloy of copper and tin; pewter.
Phlogiston	Stahl's hypothetical principle.
Phosphoric sal ammoniac	{ Ammoniacal phosphat.
	{ Phosphat of ammoniac.
Phosphoric salt of barytes	{ Phosphat barytic.
	{ Barytic phosphat.
Phosphoric salt of magnesia	Magnesian phosphat.
Phosphoric salt of potash	Phosphat of potash.
Phosphoric salt of soda	Phosphat of soda.
Phosphorus of Baldwin	Dry calcareous nitrit.
Phosphorus of Kunckel	Phosphorus.
Phosphorus of Homberg	Dry calcareous muriat.
Platina	Platina.
Plumbago	Carbure of iron.
Pompholix	Sublimated oxyd of zink.
Potash	Impure carbonat of potash.
Powder of algaroth	{ Oxyd of antimony by the mu-
	{ riatic acid.
Powder of Count de Palma	Carbonat of magnesia.
Powder of Sentinelly	Carbonat of magnesia.
Precipitate golden, or purple, of Callius	Oxyd of gold precipitated by tin.
Precipitate red	{ Red oxyd of mercury by the
	{ nitric acid.
Precipitate per se	Red oxyd of mercury by fire.
Precipitate yellow	{ Yellow oxyd of mercury by the
	{ sulphuric acid.
Precipitate white by the muriatic acid	Muriat of mercury by precipita- tion.
Principle acidifying	Oxygen.
Principle astringent	Gallic acid.
Principle inflammable.	
<i>See Phlogiston.</i>	
Principle mercurial	Beccher's hypothetical principle.
Principle of charcoal	Carbon.
Principle forbile of Ludbock	Oxygen.
Prussit calcareous	{ Calcareous prussiat.
	{ Prussiat of lime.
Prussit of soda	Prussiat of soda.
Pyrites of copper	Sulphure of copper.
Pyrites martial	Sulphure of iron.
Pyrophorus of Homberg	{ Carbonated sulphure of alumine.
	{ Pyrophorus of Homberg.

R.

Realgar	{ Red sulphurated oxyd of arse-
	{ nic.
Realgites, salts formed with aqua regia	Nitro-muriats.

*Ancient Names.**New Names.*

Regulus	-	{ A word used to signify the metallie state.
Regulus of antimony	-	Antimony.
Regulus of arsenic	-	Arsenic.
Regulus of cobalt	-	Cobalt.
Regulus of manganese	-	Manganese.
Regulus of molybdena	-	Molybdena.
Regulus of syderit	-	Phosphure of iron.
Resins	-	Resins.
Rust of copper	-	Green oxyd of copper.
Rust of iron	-	Carbonat of iron.
Ruby of antimony	-	{ Vitreous brown sulphurated oxyd of antimony.

S.

Saffron of mars	-	Oxyd of iron.
Saffron of mars, aperitive	-	Carbonat of iron.
Saffron of mars, astringent	-	Brown oxyd of iron.
Saffron of metals	-	{ Semi-vitreous sulpharated ox- yd of antimony.
Sal ammoniac	-	{ Ammoniacal muriat.
		{ Muriat of ammoniac.
		{ Calcareous muriat.
Sal ammoniac fixed	-	{ Muriat of lime.
Sal de duobus	-	Sulphat of potash.
Sal polychrest of Glaſer	-	Sulphat of potash.
Sal polychrest of Rochelle	-	Tartrit of soda.
Sal fodæ. See Soda.	-	
Salt acetous ammoniacal	-	{ Ammoniacal acetit.
		{ Acetit of ammoniac.
Salt acetous calcareous	-	{ Calcareous acetit.
		{ Acetit of lime.
Salt acetous magnesian	-	{ Magnesian acetit.
		{ Acetit of magnesia.
Salt acetous martial	-	Acetit of iron.
Salt acetous mineral	-	Acetit of soda.
Salt acetous argillaceous	-	Aluminous acetit.
Salt acetous of zinc	-	Acetit of zink.
Salt ammoniacal cretaceous	-	Ammoniacal carbonat.
		{ Calcareous muriat.
Salt ammoniacal fixed	-	{ Muriat of lime.
Salt ammoniacal nitrous	-	Nitrat of ammoniac.
Salt ammoniacal (secret of Glauber)	-	Sulphat of ammoniac.
Salt ammoniacal sedative	-	Ammoniacal borat.
Salt ammoniacal sparry	-	Fluat of ammoniac.
Salt ammoniacal vitriolic	-	Ammoniacal sulphat.

*Ancient Names.**New Names.*

Salt bitter purging	-	{ Magnesian sulphat.
Salt common	-	{ Sulphat of magnesia.
Salt febrifuge of Sylvius	-	Muriat of soda.
Salt fusible of urine	-	Muriat of potash.
Salt, Glauber's	-	Phosphat of soda and ammoniac.
Salt marine argillaceous	-	Sulphat of soda.
Salt marine calcareous	-	{ Aluminous muriat.
Salt marine magnesian	-	{ Muriat of alumine.
Salt marine of iron	-	{ Calcareous muriat.
Salt marine of zinc	-	{ Muriat of lime.
Salt native of urine	-	{ Magnesian muriat.
Salt, neutral arsenical, of Mac-	}	{ Muriat of magnesia.
quer		Muriat of iron.
Salt of alembroth	-	Muriat of zink.
Salt of amber, obtained by	}	Phosphat of soda and ammoniac.
crystallization		Acidulous arseniat of potash.
Salt of calcothar	-	Ammoniaco-mercurial muriat.
Salt of Epsom	-	Crytallized succinic acid.
Salt of jupiter	-	{ Sulphat of iron, in a state little
Salt of milk	-	{ known.
Salt of Scheidschutz	-	Sulphat of magnesia.
Salt of Sedlitz	-	Muriat of tin.
Salt of Segner	-	Sugar of milk.
Salt of Seignette.	-	Magnesian sulphat.
Salt of sorrel	-	Sulphat of magnesia.
Salt of wisdom	-	Sebat of potash.
Salt of wormwood, common	-	Tartrit of soda.
Saltpetre	-	Acidulous oxalat of potash.
Salt reguline of gold	-	Ammoniaco-mercurial muriat.
Salt sedative	-	Carbonat of potash.
Salt sedative mercurial	-	Nitrat of potash; or nitre.
Salt sedative sublimated	-	Muriat of gold.
Salt stanno-nitrous	-	Boracic acid.
Salt sulphureous of Stahl	-	Borat of mercury.
Salt vegetable	-	Sublimated boracic acid.
Salt volatile of amber	-	Nitrat of tin.
Salt, wonderful pearly	-	Sulphit of potash.
Saturn	-	Tartrit of potash.
Selenit	-	Sublimated succinic acid.
Silver	-	Superfaturated phosphat of soda.
Silver muriated	-	Lead.
Silver supernitrated	-	Sulphat of lime.
Snow of antimony	-	Silver.
		Muriat of silver.
		Fused nitrat of silver.
		{ White sublimated oxyd of an-
		{ timony.

*Ancient Names.**New Names.*

Soaps acid	-	Acid soaps.
Soaps alkaline	-	Alkaline soaps.
Soaps earthy, of Berthollet	-	Earthy soaps.
Soaps metallic, of Berthollet	-	Metallic soaps.
Soap of Starkey	-	Saponull of potash.
Soda caustic	-	Soda.
Soda cretaceous	-	Carbonat of soda.
Spanish white	-	{ White oxyd of lead by the { acetous acid.
Spar ammoniacal	-	Ammoniacal fluat.
Spar calcareous	-	Carbonat of lime.
Spar fluor	-	Calcareous fluat.
Spar ponderous	-	Sulphat of barytes.
Spirits acid	-	Acids diluted with water.
Spirit acid of wood	-	Pyroligneous acid.
Spirit alkaline volatile	-	Ammoniacal gas.
Spirit ardent	-	Alcohol.
Spirit of Mindererus	-	Ammoniacal acetit.
Spirit of nitre	-	Nitric acid diluted with water.
Spirit of nitre dulcified	-	Nitric alcohol.
Spirit of nitre fuming	-	Nitrous acid.
Spirit of salt	-	Muriatic acid.
Spirit of sal ammoniac	-	Ammoniac.
Spirit of venus	-	Acetic acid.
Spirit of vitriol	-	Sulphuric acid diluted with water.
Spirit of wine	-	Alcohol.
Spiritus rector	-	Aroma.
Spirit volatile of sal ammoniac	-	Ammoniac diluted with water.
Spiritus sylvestris, of Helmont	-	Carbonic acid.
Stone of the bladder	-	Lithic acid.
Sublimat corrosive	-	Corrosive muriat of mercury.
Sugar	-	Sugar.
Sugar candied	-	Crystallized sugar.
Sugar of lead	-	Acetit of lead.
Sugar or salt of milk	-	Sugar of milk.
Sulphur	-	Sulphur.
Sulphur golden of antimony	-	{ Orange coloured sulphurated { oxyd of antimony.
Syderit	-	Phosphat of iron.
Syderotet of Morveau	-	Phosphure of iron.

T.

Tartar	-	Acidulous tartrit of potash.
Tartar ammoniacal	-	Ammoniacal tartrit.
Tartar antimoniated	-	Antimoniated tartrit of potash.
Tartar calcareous	-	Tartrit of lime.
Tartar chalybeated	-	Ferruginous tartrit of potash.

*Ancient Names.**New Names.*

Tartar cretaceous	Carbonat of potash.
Tartar crude	Tartar.
Tartar cupreous	Tartrit of copper.
Tartar emetic	Antimoniated tartrit of potash.
Tartar of magnesia	Tartrit of magnesia.
Tartar of potash	Tartrit of potash.
Tartar of soda	Tartrit of soda.
Tartar martial soluble	Ferruginous tartrit of potash.
Tartar mephitized	Carbonat of potash.
Tartar mercurial	Mercurial tartrit.
Tartar saturnine	Tartrit of lead.
Tartar sparry, or of spar	Fluat of potash.
Tartar soluble	Tartrit of potash.
Tartar stibiatisd	Antimoniated tartrit of potash.
Tartar tartarized, or terra fo- liata tartari	Tartrit of potash.
Tartar tartarized, holding an- timony in solution	{ Tartrit of potash supercom- pounded with antimony.
Tartar vitriolated	Sulphat of potash.
Tincture acrid of tartar	Alcohol of potash.
Tinctures spirituous	Refinous alcohols.
Tin	Tin.
Tin muriated	Muriat of tin.
Tungstein	Tungstein, or Tungsten.
Turbith mineral	{ Yellow oxyd of mercury by the sulphuric acid.
Turbith nitrous	{ Yellow oxyd of mercury by the nitric acid.

V.

Verdegris	Green oxyd of copper.
Verdegris of the shops	{ Acetit of copper, with excess of oxyd.
——— distilled	Crystallized acetit of copper.
Venus	Copper.
Vinegar distilled	Acetous acid.
Vinegar of saturn	Acetit of lead.
Vinegar radical	Acetic acid.
Vitriol ammoniacal	Ammoniacal sulphat.
Vitriol blue, or Roman vitriol	Sulphat of copper.
Vitriol green, or copperas	Sulphat of iron.
Vitriol magnesian	Sulphat of magnesia.
Vitriol martial	Sulphat of iron.
Vitriol of antimony	Sulphat of antimony.
Vitriol of clay, or argile	Sulphat of alumine.
Vitriol of bismuth	Sulphat of bismuth.

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FINIS.

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TABLE I. *The Division and Characters of the Eight Classes of Animals, by* DAUBENTON.

A N I M A L S.

Having an Head.						The most part having no Head.	
With Nostrils.						Without Nostrils.	
With Ears.						Without Ears.	
Two Ventricles in the Heart.			One Ventricle in the Heart.			The Heart variously formed, or unknown.	
Warm Blood.			Blood nearly cold.			A whitish Fluid instead of Blood.	
Inspiring and expiring the Air frequently.			Inspiring and expiring the Air, at long intervals.		Admitting the Air by Gills.	Admitting the Air by Spiracula.	No apparent Entrance or Aperture to admit Air.
Viviparous.			Oviparous.				
With Teats.			Without Teats.				
1st Order.	2d Order.	3d Order.	4th Order.	5th Order.	6th Order.	7th Order.	8th Order.
QUADRUPEDS.	CETACEOUS ANIMALS.	BIRDS.	OVIPAROUS QUADRUPEDS.	SERPENTS.	FISHES.	INSECTS.	WORMS.
Four Feet, and hairy Skin.	Fins, and no Hair.	Feathered.	Four Feet, and no Hair.	Scaly, without Feet or Fins.	Scaly, with Fins.	Having Anten- næ.	Having nei- ther Feet nor Scales.

11 on 70001, 11 on 70002

11 on 70003, 11 on 70004

11 on 70005, 11 on 70006

TABLE II. *Quadrupeds, divided according to the System of BRISSON.*

		ORDERS.			SECTIONS.			GENERA.	
QUADRUPEDS,	Without teeth.	—	—	I.	—	—	{ Hairy skin	Ant-eater .	<i>Myrmecophaga.</i>
		—	—	II.	—	—	{ Scaly	Manis .	<i>Pholidotus.</i>
		With grinders only	—	III.	—	—	{ Hairy skin	Sloth .	<i>Tardigradus.</i>
		Grinders and canine teeth only	—	IV.	—	—	{ Bony covering or shell	Armadillo .	<i>Catapbraeus.</i>
		Incisive teeth in the lower jaw only	—	—	—	—	{ Two long tusks above, and a trunk	Elephant .	<i>Elephas.</i>
			—	—	—	—	{ Two long tusks below, and no trunk	Sea Cow .	<i>Odobenus.</i>
			—	—	—	—	{ Ruminant, ungulated; six incisive teeth	Camel .	<i>Camelus.</i>
			—	—	—	—	{ Ruminant, with cloven feet; eight incisive teeth. { Simple { Turned { Fore legs longer than hinder legs	Camelopardalis	<i>Giraffa.</i>
			—	—	—	—	{ { { The legs of equal length	Goat .	<i>Hircus.</i>
			—	—	—	—	{ { { Turned back	Sheep .	<i>Aries.</i>
	With teeth.	Ungulated feet.	—	—	—	—	{ { { Turned sideways	Ox .	<i>Bos.</i>
			—	—	—	—	{ { { Branched horns	Stag .	<i>Cervus.</i>
			—	—	—	—	{ { { No horns	Musk .	<i>Tragulus.</i>
			—	—	—	—	{ The hoof entire	Horse .	<i>Equus.</i>
			—	—	—	—	{ The hoof cloven	Hog .	<i>Sus.</i>
		Ungulated feet, and two incisive teeth in each jaw.	—	—	—	—	{ Three ungulated toes on each foot	Rhinoceros	<i>Rhinoceros.</i>
			—	—	—	—	{ Four ungulated toes before, three behind,	River Hog	<i>Hydrochaerus.</i>
			—	—	—	—	{ Four ungulated toes on each foot	Tapir .	<i>Tapirus.</i>
			—	—	—	—	{ { { Two incisive teeth in each jaw	River Horse	<i>Hippopotamus.</i>
			—	—	—	—	{ { { Ten incisive teeth in each jaw	Porcupine .	<i>Hystrix.</i>
	With teeth.	Incisive teeth in both jaws.	—	—	—	—	{ Prickles on the body	Beaver .	<i>Castor.</i>
			—	—	—	—	{ Without canine teeth { Without prickles. { Tail flat and scaly	Hare .	<i>Lepus.</i>
			—	—	—	—	{ { { Long ears	Coney .	<i>Cuniculus.</i>
			—	—	—	—	{ { { Short ears	Squirrel .	<i>Sciurus.</i>
			—	—	—	—	{ { { Flat	Dormouse .	<i>Glis.</i>
		Six incisive teeth in the upper, and six in the lower jaw.	—	—	—	—	{ { { Round	Rat .	<i>Mus.</i>
			—	—	—	—	{ Naked tail	Shrew Mouse	<i>Musaraneus.</i>
			—	—	—	—	{ Without prickles on the body	Hedge Hog	<i>Erinaceus.</i>
			—	—	—	—	{ With prickles	Ape .	<i>Simia.</i>
			—	—	—	—	{ Separate toes	—	<i>Pteropus.</i>
	With teeth.	Six incisive teeth in the upper, and four in the lower jaw.	—	—	—	—	{ Toes joined by a membrane so as to form wings	—	—
			—	—	—	—	{ Separate toes	Maki .	<i>Prosimia.</i>
			—	—	—	—	{ The fore toe joined so as to form wings	Bat .	<i>Vespertilio.</i>
			—	—	—	—	—	Seal .	<i>Phoca.</i>
			—	—	—	—	—	Hyæna .	<i>Hyæna.</i>
	With teeth.	Six incisive teeth in each jaw.	—	—	—	—	—	Dog .	<i>Canis.</i>
			—	—	—	—	—	Weazel .	<i>Mustela.</i>
			—	—	—	—	—	Badger .	<i>Meles.</i>
			—	—	—	—	—	Beaver .	<i>Ursus.</i>
			—	—	—	—	—	Cat .	<i>Felis.</i>
		Six incisive teeth in the upper, and eight in the lower jaw.	—	—	—	—	—	Otter .	<i>Lutra.</i>
			—	—	—	—	—	Mole .	<i>Talpa.</i>
			—	—	—	—	—	Opoffum .	<i>Philander.</i>
			—	—	—	—	—	—	—
			—	—	—	—	—	—	—
			—	—	—	—	—	—	—



		ORDERS.		SECTIONS.		GENERA.	
BIRDS ARE	The legs feathered as low as the calcaneum, or bone which sustains the toes.	Four toes all separate from each other, quite to their base.	Three toes before, and one behind.	I.	The beak frnit; the upper mandible thickened, and somewhat curved at the point; the nostrils half covered with a thick soft membrane. It consists of one genus only.	Pigeon	<i>Columba</i> .
				II.	The beak conical and curved. It consists of six genera.	Turkey	<i>Gallus Pavo</i> .
						Cock and Hen	<i>Gallus</i> .
				III.	The beak short and crooked. It consists of five genera.	Guinea Hen	<i>Meleagris</i> .
						Guinea	<i>Lagopus</i> .
				IV.	The beak long and conical. It consists of six genera.	Partridge	<i>Perdix</i> .
						Pheasant	<i>Phasianus</i> .
				V.	The beak frnit; the upper mandible grooved on each side towards the point. It consists of four genera.	Hawk	<i>Accipiter</i> .
						Eagle	<i>Aquila</i> .
				VI.	The beak frnit, and the mandibles not grooved. It consists of two genera.	Vulture	<i>Vultur</i> .
						Owl	<i>Syrinx</i> .
				VII.	The beak slender, and rather bent. It consists of two genera.	Chough	<i>Coracias</i> .
						Crow	<i>Corvus</i> .
				VIII.	The beak very small, flattened horizontally at its base, and bent at the point; the opening of the mouth appears larger than the head. It consists of two genera.	Magpie	<i>Pica</i> .
						Roller	<i>Galgula</i> .
				IX.	The beak conical, and gradually diminishing to the point. It consists of eight genera.	oriole	<i>Icterus</i> .
						Bird of Paradise	<i>Manucodonta</i> .
				X.	The beak awl-shaped. It consists of three genera.	Butcher Bird	<i>Lanius</i> .
						Thrush	<i>Turdus</i> .
				XI.	The beak wedge-shaped. It consists of one genus only.	Chatterer	<i>Cotinga</i> .
						Fly-catcher	<i>Muscicapa</i> .
				XII.	The beak filiform. It consists of three genera.	Beef-eater	<i>Buphagus</i> .
						Starling	<i>Sturnus</i> .
				XIII.	Consisting of nine genera.	Hoopoe	<i>Upupa</i> .
						Promerops	<i>Promerops</i> .
	The middle to be united with the exterior for the space of three phalanges, and with the interior for the space of one phalanx; four toes; three before, and one behind.	Wings too small for flight.	Two toes before, and two behind.	XIV.	seven genera.	Goat-fucker	<i>Caprimulgus</i> .
						Swallow	<i>Hirundo</i> .
				XV.	four genera.	Tanager	<i>Tangara</i> .
						Goldfinch	<i>Carduelis</i> .
				XVI.	four genera.	Sparrow	<i>Passer</i> .
						Grobbek	<i>Coccothraustes</i> .
				XVII.	eighteen genera.	Bunting	<i>Emberiza</i> .
						Cole	<i>Colinus</i> .
				XVIII.	three genera.	Bullfinch	<i>Pyrrhula</i> .
						Crookbill	<i>Loxia</i> .
				XIX.	one genus.	Lark	<i>Alauda</i> .
						Beccaftco	<i>Ficedula</i> .
				XX.	three genera.	Tit-mouse	<i>Parus</i> .
						Nuthatch	<i>Sitta</i> .
	The lower part of the legs without feathers.	Wings large enough for flight.	Three toes before, and one behind.	XXI.	three genera.	Creepers	<i>Certhia</i> .
						Humming Bird	<i>Polyommus</i> .
				XXII.	one genus.	Wren	<i>Melospiza</i> .
						Wood pecker	<i>Troglodytes</i> .
				XXIII.	six genera.	Jacamar	<i>Galbula</i> .
						Barbet	<i>Bucco</i> .
				XXIV.	three genera.	Cuckoo	<i>Cuculus</i> .
						Curlew	<i>Tringoides</i> .
				XXV.	five genera.	Ani	<i>Crotophaga</i> .
						Parrot	<i>Falcon</i> .
				XXVI.	three genera.	Toucan	<i>Toucan</i> .
						Manakin	<i>Rapicola</i> .
				XXVII.	one genus.	Momot	<i>Momotus</i> .
						King-fisher	<i>Alcedo</i> .
	The membranes of the feet divided. Four toes; three before and one behind, which are divided, and have membranous edges.	The legs placed behind near the anus.	Three toes before, connected by a membrane; no toes behind.	XXVIII.	three genera.	Emu	<i>Rhea</i> .
						Calloway	<i>Callorhynchus</i> .
				XXIX.	one genus.	Dodo	<i>Raphus</i> .
						Buffard	<i>Otis</i> .
				XXX.	three genera.	Long Legs	<i>Ostrich</i> .
						Oyster-catcher	<i>Hydrocorax</i> .
				XXXI.	three genera.	Flower	<i>Phalaropus</i> .
						Lapwing	<i>Vanellus</i> .
				XXXII.	one genus.	Jacana	<i>Jacana</i> .
						Turnstone	<i>Arenaria</i> .
				XXXIII.	six genera.	Pratincole	<i>Glareola</i> .
						Rail	<i>Rallus</i> .
				XXXIV.	three genera.	Sandpiper	<i>Tringa</i> .
						Godwit	<i>Limosa</i> .
	The membranes partly divided; the toes joined together near their base; the legs placed behind near the anus.	The legs placed in the middle of the body, and shorter than it.	Three toes before, and one behind.	XXXV.	five genera.	Woodcock	<i>Scolopax</i> .
						Curlew	<i>Numenius</i> .
				XXXVI.	three genera.	Spoonbill	<i>Plataea</i> .
						Stork	<i>Ciconia</i> .
				XXXVII.	one genus.	Heron	<i>Ardea</i> .
						Umbre	<i>Scopus</i> .
				XXXVIII.	three genera.	Boat bill	<i>Cochlearius</i> .
						Crown Bird	<i>Balearcica</i> .
				XXXIX.	one genus.	Cariama	<i>Cariama</i> .
						Screamer	<i>Anhinga</i> .
				XL.	three genera.	Gallinule	<i>Porphyrio</i> .
						Water-Hen	<i>Gallinula</i> .
				XLI.	three genera.	Phalaropus	<i>Phalaropus</i> .
						Coot	<i>Fulica</i> .
	The legs longer than the body.	The four toes connected by a membrane.	Three toes before, connected by a membrane; one separate toe behind.	XLII.	one genus.	Grebe	<i>Colymbus</i> .
						Guillemot	<i>Uria</i> .
				XLIII.	six genera.	Puffin	<i>Fratercula</i> .
						Auk	<i>Alca</i> .
				XLIV.	three genera.	Penguin	<i>Spheniscus</i> .
						Marquis	<i>Charadrius</i> .
				XLV.	one genus.	Diver	<i>Albatrus</i> .
						Shearwater	<i>Puffinus</i> .
				XLVI.	three genera.	Petrel	<i>Procellaria</i> .
						Arctic Bird	<i>Larus</i> .
				XLVII.	five genera.	Gull	<i>Larus</i> .
						Tern	<i>Sterna</i> .
				XLVIII.	three genera.	Razorbill	<i>Hydrochelidon</i> .
						Merganser	<i>Merganser</i> .
				XLIX.	three genera.	Goose	<i>Anser</i> .
						Duck	<i>Anas</i> .
				L.	three genera.	Dartar	<i>Anhinga</i> .
						Tropic Bird	<i>Lophyrus</i> .
				LI.	three genera.	Booby	<i>Sula</i> .
						Cormorant	<i>Phalacrocorax</i> .
				LII.	three genera.	Pelican	<i>Oncorhynchus</i> .
						Flamingo	<i>Phoenicopterus</i> .
				LIII.	three genera.	Avocet	<i>Avocetta</i> .
						Courier	<i>Corvinus</i> .

TABLE IV. *The Division of Oviparous Quadrupeds, by* DAUBENTON.

OVIPAROUS
QUADRUPEDS.

CLASS I. The body covered with a shell.
TORTOISES. } Consisting of 15 species.

Genus I. Lizards
which have the body
somewhat tuberculated, and the
tail flat. } Consisting of 8 species.

Genus II. Lizards
which have the tail
verticillated. } Consisting of 12 species.

CLASS II. The body
naked, with a tail.

LIZARDS.

Genus III. Lizards
which have the tail
round, scaly, and
shorter than the body. } Consisting of 5 species.

Genus IV. Lizards
which have the tail
round, scaly, and
longer than the body. } Consisting of 17 species.

Genus V. Lizards
which have four
toes on the fore-
feet, and the body
smooth. } Consisting of 5 species.

Genus VI. Winged
Lizards. } The Dragon.

CLASS III. The body
naked, without a tail.

Genus I. Toads;
the body round,
and tuberculated,
the legs short. } Consisting of 14 species.

Genus II. Frogs
which have the
body long. } Consisting of 11 species.

Genus III. Frogs
which have the
toes terminating in
a broad flat sur-
face. } Consisting of 9 species.



TABLE V. *A Methodical Table of Oviparous Quadrupeds, by M. DE LA CEPEDE.*

CLASS I. Oviparous Quadrupeds which have a Tail.

CLASS II. Oviparous Quadrupeds which have no Tail.

FIRST GENUS.

TORTOISES.

The body covered with a hard or continuous covering.

SECOND GENUS.

LIZARDS.

The body without a hard or continuous covering.

FIRST GENUS.

WATER FROGS.
(GRENOUILLES.)

The head and body long, the one
or the other angular.

SECOND GENUS.

FROGS.
(P. ALINES.)

The body long, and viscid balls
beneath the toes.

THIRD GENUS.

TOADS.
(CRAPAUDS.)

The body short and round.

I. DIVISION.		II. DIVISION.		III. DIVISION.		IV. DIVISION.		IV. DIVISION continued.		VI. DIVISION.	
The toes very unequal, and elongated in the form of flukes.		The toes very short, and nearly equal.		The tail flattened, five toes on the fore feet.		The tail round, five toes on each foot and scales raised on the back in the form of a crest or comb.		The tail round, five toes on the fore feet, with scaly bands under the belly.		Three toes on the fore and hind feet.	
SPECIES.	CHARACTERS.	SPECIES.	CHARACTERS.	SPECIES.	CHARACTERS.	SPECIES.	CHARACTERS.	SPECIES.	CHARACTERS.	SPECIES.	CHARACTERS.
<i>Tortue franche</i> .	A single sharp claw on each hind foot.	Yellow T. <i>T. Juana</i> .	The shell green, with yellow spots.	<i>Crocodile</i> .	Four palmated toes on the hind feet, the colour of yellowish green.	Grey L. <i>L. Grit.</i>	Colour grey, with large scales on the neck.	<i>Caméléon</i> .	The toes united three and three, and two and two by a membrane.	Marbled L. <i>L. Marbre.</i>	part of the nails black, the tail relieved by five longitudinal ridges.
<i>Tortue d'Inde</i> .	Having green scales on the shell.	Soft T. <i>T. Mille</i> .	The covering soft, and without any scales, properly so called.	Black <i>Crocodile</i> .	Four palmated toes on the hind feet, the colour black.	Green L. <i>L. Vert.</i>	Colour green, large scales beneath the neck.	<i>Blue tail</i> .	Five yellowish rays upon the back, the tail black.	<i>Rouge</i> .	The colour of dead leaves, with yellow and blackish spots, a small membrane on each side of the extremity of the toes.
<i>Cassare</i> .	Two sharp claws on each hind foot.	Greek T. <i>T. Græque</i> .	The covering very convex, the borders very broad, the toes covered by a membrane.	<i>Gavial</i> .	Four palmated toes on the hind feet, the jaws very narrow and long.	<i>Cordyle</i> .	The tail furnished with very long scales, terminating in long spikes, which form large felted rings.	<i>Azure L.</i>	Pointed scales, the back blue.	<i>Rouge Gorge</i> .	The colour green, a red velvet under the throat.
<i>T. Nigroline</i> .	An elevated tubercle on the nose.	Geometrical T. <i>T. Géométrique</i> .	Yellow radii, which unite upon each scale in a centre of the same colour.	<i>Whiptail</i> .	Five palmated toes on the hind feet.	Hexagonal L. <i>L. Hexagone</i> .	The tail presenting five very prominent ridges.	<i>Grifon</i> .	A callosity upon the occiput, a fold underneath the throat.	<i>Goitreux L.</i>	The colour grey, mixed with brown, pouched underneath with small reddish grains under the throat.
<i>Caret</i> .	The scales of the shell placed one over the other like tiles.	<i>Pauch Tortoise</i> .	The scales whitish exhibiting very narrow blackish bands, those of the middle of the disc rising in ridges, the breast plate fellooned before.	<i>Dragon</i> .	Five separate toes on the hind feet, raised scales in the form of a crest upon the tail.	<i>Ameiva</i> .	The colour grey or green, without large scales under the neck.	<i>Folded L.</i>	Two folds beneath the throat, two warts or protuberances, with points behind the opening of the ears.	<i>Tégua</i> .	Many folds along the sides of the body.
<i>Luth</i> .	The covering of the confidence of leather, and having five ridges, longitudinal.	<i>Raboteuse</i> .	The covering somewhat in the form of a beard, the edges of the covering very much indented.	<i>Tupinambá</i> .	Separate toes on each foot, the scales oval, surrounded with very small tubercles, and not raised in the form of a crest.	<i>L. Lyon</i> .	Three white rays and three black rays on each side of the back.	<i>Algir</i> .	Four yellow rays on the back.	<i>Triangular L.</i>	The extremity of the tail in the form of a three sided pyramid.
II. DIVISION.		Indented <i>Tortoise</i> .	Covering very convex, the scales greenish, radiated with yellow, the breast-plate oval.	<i>L. Saucilleux</i> .	A prominent ridge over the eyes, and the scales raised in the form of a crest from the head to the tail.	<i>Agave</i> .	From seven to eleven whitish bands upon the back, the thighs spotted with white.	<i>Stellion</i> .	The whole body covered with sharp tubercles, the tail covered with indented rings.	<i>Double Striped L.</i>	Two stripes of adirity yellow, and six rows of blackish points upon the back.
The toes very short, and small, pointed.		<i>Dentelle</i> .	The scales of the covering variegated with black, white, purple, greenish, and yellow.	<i>Forked head</i> .	Two eminent ridges upon the head.	<i>L. Galonné</i> .	The tail covered with white.	<i>Scingue</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.	<i>Spateur</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.
The toes very short, and small, pointed.		Convex T. <i>T. Bombe</i> .	The covering very convex, the scales greenish, radiated with yellow, the breast-plate oval.	<i>L. Saucilleux</i> .	A prominent ridge over the eyes, and the scales raised in the form of a crest from the head to the tail.	<i>Agave</i> .	From seven to eleven whitish bands upon the back, the thighs spotted with white.	<i>Scingue</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.	<i>Spateur</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.
The toes very short, and small, pointed.		Vermillion T. <i>T. Vermillon</i> .	The covering very convex, the scales greenish, radiated with yellow, the breast-plate oval.	<i>L. Saucilleux</i> .	A prominent ridge over the eyes, and the scales raised in the form of a crest from the head to the tail.	<i>Agave</i> .	From seven to eleven whitish bands upon the back, the thighs spotted with white.	<i>Scingue</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.	<i>Spateur</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.
The toes very short, and small, pointed.		Short-tailed <i>Tortoise</i> .	The covering very convex, the scales greenish, radiated with yellow, the breast-plate oval.	<i>L. Saucilleux</i> .	A prominent ridge over the eyes, and the scales raised in the form of a crest from the head to the tail.	<i>Agave</i> .	From seven to eleven whitish bands upon the back, the thighs spotted with white.	<i>Scingue</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.	<i>Spateur</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.
The toes very short, and small, pointed.		<i>T. Courte</i> .	The covering very convex, the scales greenish, radiated with yellow, the breast-plate oval.	<i>L. Saucilleux</i> .	A prominent ridge over the eyes, and the scales raised in the form of a crest from the head to the tail.	<i>Agave</i> .	From seven to eleven whitish bands upon the back, the thighs spotted with white.	<i>Scingue</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.	<i>Spateur</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.
The toes very short, and small, pointed.		<i>T. Courte</i> .	The covering very convex, the scales greenish, radiated with yellow, the breast-plate oval.	<i>L. Saucilleux</i> .	A prominent ridge over the eyes, and the scales raised in the form of a crest from the head to the tail.	<i>Agave</i> .	From seven to eleven whitish bands upon the back, the thighs spotted with white.	<i>Scingue</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.	<i>Spateur</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.
The toes very short, and small, pointed.		<i>T. Courte</i> .	The covering very convex, the scales greenish, radiated with yellow, the breast-plate oval.	<i>L. Saucilleux</i> .	A prominent ridge over the eyes, and the scales raised in the form of a crest from the head to the tail.	<i>Agave</i> .	From seven to eleven whitish bands upon the back, the thighs spotted with white.	<i>Scingue</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.	<i>Spateur</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.
The toes very short, and small, pointed.		<i>T. Courte</i> .	The covering very convex, the scales greenish, radiated with yellow, the breast-plate oval.	<i>L. Saucilleux</i> .	A prominent ridge over the eyes, and the scales raised in the form of a crest from the head to the tail.	<i>Agave</i> .	From seven to eleven whitish bands upon the back, the thighs spotted with white.	<i>Scingue</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.	<i>Spateur</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.
The toes very short, and small, pointed.		<i>T. Courte</i> .	The covering very convex, the scales greenish, radiated with yellow, the breast-plate oval.	<i>L. Saucilleux</i> .	A prominent ridge over the eyes, and the scales raised in the form of a crest from the head to the tail.	<i>Agave</i> .	From seven to eleven whitish bands upon the back, the thighs spotted with white.	<i>Scingue</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.	<i>Spateur</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.
The toes very short, and small, pointed.		<i>T. Courte</i> .	The covering very convex, the scales greenish, radiated with yellow, the breast-plate oval.	<i>L. Saucilleux</i> .	A prominent ridge over the eyes, and the scales raised in the form of a crest from the head to the tail.	<i>Agave</i> .	From seven to eleven whitish bands upon the back, the thighs spotted with white.	<i>Scingue</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.	<i>Spateur</i> .	The whole body covered with scales placed over each other like roof plates, the upper jaw further advanced than the lower.

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TABLE VI. *The Division of Serpents, by* DAUBENTON.

S E R P E N T S.	Genus I. Rattle-snakes; or such as have a Rattle at the extremity of the tail. Crotalus, Linnæi.	} It consists of four species.
	Genus II. Serpents which have large scales (Scuta) beneath the body and tail; without a Rattle. Boa, Linn.	} It consists of ten species.
	Genus III. Serpents which have large scales (Scuta) beneath the body, and small scales (Squamæ) beneath the tail. Coluber, Linn.	} It consists of ninety-six species.
	Genus IV. Serpents which have small scales beneath the body and tail. Anguis, Linn.	} It consists of thirteen species.
	Genus V. Serpents which have the body divided into annuli or rings. Amphibæna, Linn.	} It consists of two species.
	Genus VI. Serpents which have the skin naked and smooth. Cæcilia, Linn.	} It consists of two species.



TABLE VII. *The Ichthyologic System of GOUAN.*

FISHES
HAVE

EITHER

The gills perfect

Class I. ACANTHOPTERYGII.
The fins supported by small bones.

Order I. Apodes.
The ventral fins wanting.

- { 1. ——— - *Trichiurus.*
2. Sword-fish - *Xipbias.*
3. ——— - *Ophidium.*

Order II. Jugulares
The belly-fins placed beneath
the neck.

- { 1. Weveer - *Trachinus.*
2. ——— - *Uranosque.*
3. Dragonet - *Callyonymus.*
4. Blenny - *Blennius.*

Order III. Thoracici.
The ventral fins placed beneath
the breast.

- { 1. Goby - *Gobius.*
2. ——— - *Cepola.*
3. Dolphin - *Coryphæna.*
4. Mackrel - *Scomber.*
5. Wrasse - *Labrus.*
6. Gilthead - *Sparus.*
7. ——— - *Chaetodon.*
8. ——— - *Sciaena.*
9. Perch - *Perca.*
10. Father Lasher - *Scorpaena.*
11. Surmullet - *Mullus.*
12. Gurnard - *Trigla.*
13. Bull-head - *Cottus.*
14. Doree - *Zeus.*
15. ——— - *Trachipterus.*
16. Stickle-back - *Casterosteus.*

Order IV. Abdominales.
The ventral fins placed beneath
the abdomen.

- { 1. Catfish - *Silurus.*
2. Mullet - *Mugil.*
3. ——— - *Polynemus.*
4. ——— - *Theutys.*
5. ——— - *Elops.*

Order I. Apodes.

- { 1. Eel - *Murana.*
2. Gymnotus - *Gymnotus.*
3. Wolf-fish - *Anarhichas.*
4. ——— - *Stromateus.*
5. Launce - *Anmodytes.*

Order II. Jugulares.

- { 1. ——— - *Lepadogaster.*
2. Cod - *Gadus.*

Order III. Thoracici.

- { 1. Flounder - *Pleuroneles.*
2. Sucking-fish - *Echeneis.*
3. ——— - *Lepidopus.*

Order IV. Abdominales.

- { 1. ——— - *Loricaria.*
2. Atherine - *Atherina.*
3. Salmon - *Salmo.*
4. ——— - *Fisularia.*
5. Pike - *Esox.*
6. Argentine - *Argentina.*
7. Herring - *Clupea.*
8. Flying-fish - *Exocoetus.*
9. Carp - *Cyprinus.*
10. Loche - *Cobitis.*
11. ——— - *Amia.*
12. ——— - *Mormyrus.*

Order I. Apodes.

- { 1. Pipe-fish - *Syngnathus.*
2. Balistes - *Balistes.*
3. ——— - *Ostracion.*
4. ——— - *Tetraodon.*
5. Sun-fish - *Diodon.*

Order II. Jugulares.

1. Angler - *Lophius.*

Order III. Thoracici.

1. Lump-fish - *Cyclopterus.*

Order IV. Abdominales.

- { 1. ——— - *Centrifcus.*
2. ——— - *Pegasus.*

OR

The gills imperfect.

Class III. BRONCHIOTEGI.



TABLE VIII. *The Entomologic Method of GEOFFROY.*



TABLE IX. Exhibiting the CHEMICAL NOMENCLATURE proposed by Messieurs DE MORVEAU, LAVOISIER, and DE FOURCROY, in May 1787.

I.		II.		III.		IV.		V.		VI.	
SUBSTANCES THAT HAVE NOT BEEN YET DECOMPOSED.		THE SAME SUBSTANCES REDUCED INTO THE STATE OF GAS BY THE ADDITION OF CALORIC.		THE SAME SUBSTANCES COMBINED WITH OXYGEN.		THE SAME SUBSTANCES IN AN OXYGENATED GASEOUS STATE.		THESE OXYGENATED SUBSTANCES NEUTRALIZED BY THE ADDITION OF BASES.		THE SAME PRIMARY SUBSTANCES COMBINED WITH OTHER SUBSTANCES, BUT NOT ACIDIFIED.	
NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.	NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.	NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.	NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.	NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.	NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.
Light Caloric	—	Latent heat, or matter of heat.	—	—	—	—	—	—	—	—	—
Oxygen	—	The base of vital air.	Oxygenous gas. N.B. It appears that light contributes to the reduction of oxygen into a gaseous state.	Dephlogisticated, or vital air.	—	—	—	Nitrate of potash. of foda, &c.	Common nitre. Cubic nitre.	Carbure of iron.	Plumbago.
Hydrogen.	—	The base of inflammable gas.	Hydrogenous gas.	Inflammable gas.	Water.	—	—	Nitrite of potash. of foda, &c.	Common nitre. Cubic nitre.	—	—
Azot, or the radical principle of the nitric acid.	—	The base of phlogisticated air, or of atmospheric mephitic gas.	Gas azot.	Phlogisticated air, or atmospheric mephitic gas.	The base of nitrous gas. Nitric acid. With an excess of azot, Nitrous acid. Carbonic acid.	Nitrous gas. Nitrous acid gas.	—	Nitrate of potash. of foda, &c.	Common nitre. Cubic nitre.	—	—
Carbon, or the radical principle of the carbonic acid.	Pure coal.	—	—	—	Fuming nitrous acid. Fixed air, or cretaceous acid.	Carbonic acid gas.	Fixed air, mephitic air.	Nitrite of potash. of lime. Effluvescent alkaline nat. of iron, &c.	Chalk. Effluvescent alkaline nat. of iron, &c.	Carbure of iron.	Plumbago.
Sulphur, or the radical principle of the sulphuric acid.	—	—	—	—	Sulphuric acid. With less oxygen, Sulphurous acid.	Sulphuric acid.	—	Sulphate of potash. of lime. Glauber salt. of alumine. Alum. Ponderous spar. of iron, &c.	Sulphate of potash. of lime. Glauber salt. of alumine. Alum. Ponderous spar. of iron, &c.	Sulphure of iron. Syderite.	—
Phosphor, or the radical principle of the phosphoric acid.	—	—	—	—	Phosphoric acid.	Phosphoric acid.	—	Phosphate of foda. of lime. Calcareous phosphate. Superfaturated phosphate of foda. Phosphate of potash. &c.	Phosphoric salt, with less of vitrum. Earth of bones. Haupt's sal perlatum.	—	—
Radical principle of the muriatic acid.	—	—	—	—	Muriatic acid. With an excess of oxygen.	Muriatic acid gas.	Muriatic acid gas.	Muriate of potash. Muriate of lime. Calcareous muriat, &c.	Hydrofluoric salt of Sydenham. Marine salt. Calcareous marine salt. Sal ammoniac.	—	—
Radical principle of the boracic acid.	—	—	—	—	Oxygenated muriatic acid. Boracic acid.	Oxygenated muriatic acid gas.	Dehydrofluorated muriatic acid gas.	Borat superfaturated with foda, or borax. Borat of foda, &c. foda saturated with the oil. Fluat of lime, &c.	Common borax.	—	—
Radical principle of the fluoric acid.	—	—	—	—	Fluoric acid.	Acid of spar.	Fluoric acid gas.	Succinat of foda, &c.	Fluor spar.	—	—
Radical principle of the succinic acid.	—	—	—	—	Succinic acid.	Volatile salt of amber.	—	—	—	—	—
Radical principle of the acetic acid.	—	—	—	—	Acetous acid.	Distilled vinegar.	—	—	—	—	—
Radical principle of the tartareous acid.	—	—	—	—	Pyro tartareous acid.	Emphyreumatic tartareous acid, or spirit of tartar.	—	—	—	—	—
Radical principle of the oxalic acid.	—	—	—	—	Oxalic acid.	Saccharine acid.	—	—	—	—	—
Radical principle of the gallic acid.	—	—	—	—	Gallic acid.	Astringent principle.	—	—	—	—	—
Radical principle of the citric acid.	—	—	—	—	Citric acid.	Lemon juice.	—	—	—	—	—
Radical principle of the malic acid.	—	—	—	—	Malic acid.	Acid of apples.	—	—	—	—	—
Radical principle of the benzoic acid.	—	—	—	—	Benzolic acid.	Flowers of benzoil.	—	—	—	—	—
Radical principle of the pyro-ligneous acid.	—	—	—	—	Pyro-ligneous acid.	Spirit of wood.	—	—	—	—	—
Radical principle of the pyro-mucous acid.	—	—	—	—	Pyro-mucous acid.	Spirit of honey, sugar, &c.	—	—	—	—	—
Radical principle of the camphoric acid.	—	—	—	—	Camphoric acid.	—	—	—	—	—	—
Radical principle of the lactic acid.	—	—	—	—	Lactic acid.	Acid of milk.	—	—	—	—	—
Radical principle of the saccholactic acid.	—	—	—	—	Saccholactic acid.	Acid of sugar of milk.	—	—	—	—	—
Radical principle of the formic acid.	—	—	—	—	Formic acid.	Acid of ants.	—	—	—	—	—
Radical principle of the prufic acid.	—	—	—	—	Prufic acid.	Colouring matter of Pruffian blue.	—	—	—	—	—
Radical principle of the sebatic acid.	—	—	—	—	Sebatic acid.	Acid of grease.	—	—	—	—	—
Radical principle of the lithic acid.	—	—	—	—	Lithic acid.	Stone in the bladder.	—	—	—	—	—
Radical principle of the bombic acid.	—	—	—	—	Bombic acid.	Acid of the silk-worm.	—	—	—	—	—
OXYDS WITH VARIOUS BASES.											
Arsenic	Regulus of arsenic.	—	—	Oxyd of arsenic. With more oxygen. Arsenic acid.	White arsenic, or calx of arsenic. Arsenic acid.	Yellow fulphurated oxyd of arsenic. Red oxyd of arsenic.	Opiment. Resinifer.	Arseniat of potash, &c.	Macquer's arsenical neutral salt.	Alloy of arsenic and tin.	—
Molybdens.	—	—	—	Oxyd of molybdens. Molybdic acid.	Calx of molybdens.	—	—	Arseniat of copper.	—	Alloy, &c.	—
Tungsten.	—	—	—	Oxyd of tungsten. Tungstic acid.	Calx of tungsten.	—	—	Molybdat.	—	Alloy, &c.	—
Manganese.	Regulus of manganese.	—	—	Oxyd of manganese. Manganic acid.	Manganese.	—	—	Calcareous tagblat.	Swedisch tungsten.	Alloy of manganese and iron.	—
Nickel.	—	—	—	White oxyd of nickel. Black oxyd of nickel.	Calx of nickel.	—	—	—	—	Alloy of nickel, &c.	—
Cobalt.	Regulus of cobalt.	—	—	Oxyd of cobalt. Vitreous cobalt.	Calx of cobalt.	—	—	—	—	Alloy, &c.	—
Bismuth.	—	—	—	White oxyd of bismuth. Yellow vitreous bismuth.	Magistery of bismuth, or white paint. Yellow calx of bismuth. Calx of bismuth.	Alkaline cobaltic oxyd. Sulphurated oxyd of bismuth.	Præcipitatus of cobalt again dissolved by alkalis. Bismuth præcipitated by liver of sulphur.	—	—	Alloy, &c.	—
Antimony.	Regulus of antimony.	—	—	White oxyd of antimony. Vitreous antimony.	by the nitrous acid. Powder of Algarotti. Flowers, or snow of antimony. Calx of regular antimony.	Grey Red Orange Vitreous	Grey calx of antimony. Kermes mineral. Golden sulphur. Glafs and liver of antimony. Retzou's solvent.	—	—	Alloy, &c.	—
Zinc.	—	—	—	Oxyd of zinc. Sublimated oxyd of zinc.	Calx of zinc. Flowers of zinc, pom-pas, &c.	—	—	—	—	Alloy, &c.	—
Iron.	—	—	—	Black oxyd of iron. Red oxyd of iron.	Muriat of iron. Astringent saffron of Mars.	—	—	—	—	Alloy, &c.	—
Tin.	—	—	—	White oxyd of tin.	Calx, or putty of tin.	—	—	—	—	Alloy, &c.	—
Lead.	—	—	—	White oxyd of lead. Yellow oxyd of lead. Red vitreous lead.	Cerule, or white lead. Massicot. Minium. Litharge.	—	—	—	—	Alloy, &c.	—
Copper.	—	—	—	Green oxyd of copper. Blue vitreous copper.	Brown calx of copper. Green calx of copper, or verdigris. Mountain blue.	—	—	—	—	Alloy, &c.	—
Mercury.	—	—	—	Blackish Yellow oxyd. Red oxyd of silver.	Mercurial oxyd. Turbith mineral. Precipitate per se. Calx of silver.	—	—	—	—	Alloy or amalgam of, &c.	—
Platina.	—	—	—	Oxyd of platina.	Calx of platina.	—	—	—	—	Alloy, of platina & gold.	—
Gold.	—	—	—	Oxyd of gold.	Calx of gold.	—	—	—	—	Alloy, &c.	—
Siles.	Fluissable earth quartz.	—	—	—	—	—	—	—	—	—	—
Alumine.	Clay, or earth of alum.	—	—	—	—	—	—	—	—	—	—
Barytes.	Terra ponderosa.	—	—	—	—	—	—	—	—	—	—
Lime.	Calcareous earth.	—	—	—	—	—	—	—	—	—	—
Magnesia.	—	—	—	—	—	—	—	—	—	—	—
Potash.	Vegetable fixed alkali of tartar, &c.	—	—	—	—	—	—	—	—	—	—
Soda.	Mineral alkali, marine alkali, natrum.	—	—	—	—	—	—	—	—	—	—
Ammoniac.	Flour, or caustic volatile alkali.	Ammoniacal gas.	Alkaline gas.	—	—	—	—	—	—	—	—

DENOMINATIONS newly appropriated to several Substances, which are more compound in their Nature, yet enter into new Combinations without being decomposed.

New Names.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Mucous matter.	Gluinous matter, or gluten.	Sugar.	Starch.	Fixed oil.	Volatile oil.	The aroma, or aromatic principle.	Refin.	Extractive matter.	Extra-ordinary matter.	In which the extractive matter predominates.	Refined extractive matter.	In which the resin predominates.	Feculum.	Alcohol, or spirit of wine.	Alcohol.	Nitrous Callic Muriatic	Alkaline earthy soaps.
Ancient Name.	Mucilage.	Gluinous matter.	Saccharine matter.	Amylaceous matter.	Fat oil.	Essential oil.	Spiritus rectif.	Refin.	Extractive matter.	—	—	—	Feculum.	Spirit of wine.	Alcohol.	Essence of tartar, Marine ether.	Alkaline earthy soaps.

* As the substances in the lower part of the column cannot be reduced into a gaseous state, and not only they, but several of those in the upper part; we have therefore changed at this place the title of the column, and substituted another, which expresses the peculiar combinations of the masses.

